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AN ELASTIC-PLASTIC FINITE ELEMENT ANALYSIS OF NOTCHED ALUMINUM PANELS

Michael John Kaiser

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN ELASTIC-PLASTIC FINITE ELEMENT ANALYSIS OF NOTCHED ALUMINUM PANELS

by

Michael John Kaiser

March 1981

Thesis Advisor: G. H. Lindsey

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T199335

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
An Elastic-Plastic Finite Element Analysis of Notched Aluminum Panels

5. TYPE OF REPORT & PERIOD COVERED
Master's Thesis
March 1981

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Michael John Kaiser

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
March 1981

13. NUMBER OF PAGES
155 pages

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Finite element analysis, stress, stress concentration factor, notched panels, residual stress, plastic zone, ADINA, extrapolation, elastic-plastic stress.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
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S/N 0102-014-6601

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An Elastic-Plastic Finite Element Analysis of Notched Aluminum Panels

by

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Lieutenant Commander, United States Navy
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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
March 1981

ABSTRACT

Finite element, elastic and plastic analyses of various aluminum panels, containing holes and notches, were conducted for comparison with photoelastic experimental results. A FORTRAN IV program, ADINA (Automatic Dynamic Incremental Nonlinear Analysis), was used for both linear and nonlinear analyses. Mesh refinements were used for each panel and the monotonically convergent results were extrapolated using Richardson's method. Stresses were locally smoothed from the Gauss integration points to the nodal points. Eight noded, isoparametric elements were used throughout. Modification to an ADINA preprocessor program, also coded in FORTRAN IV, was made for use with a VERSATEC plotter.

Comparisons were made to the elastic, analytic series solution by Howland for a circular hole in a finite strip. The finite element results varied by less than one percent from Howland's solution. Handbook values for the elastic stress concentration factors of the geometries investigated differ from finite element results by less than one percent in all cases. The photoelastic works of Frocht were also compared where applicable. Stresses in the plastic range obtained from slip-line theory for a rigid-perfectly-plastic material show excellent correlation to a finite element analysis of such a material. Comparisons to elastic and plastic experimental data were made for the panels analyzed and show good correlation to finite element results.

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SYMBOLS AND ABBREVIATIONS

ADINA	Automatic Dynamic Incremental Nonlinear Analysis
b	Half width of strip
CPU	Central processor unit
E	Young's Modulus of Elasticity
E_t	Strain hardening tangent modulus
FEA	Finite element analysis
JCL	Job control language
K_T	Stress concentration factor referenced to reduced cross-section σ/σ_n
MVS	Multiple virtual storage
n	Ramberg-Osgood exponent
$O(h^m)$	Order of the discretization error
r	Radius of hole or notch
VM	Virtual machine
β	Ramberg-Osgood coefficient
ε	General representation for strain
λ	Non-dimensional size parameter $\lambda=r/b$
ν	Poisson's Ratio of transverse strain
σ	General representation for stress
σ_θ	Principle stress in θ direction (hoop stress)
σ_r	Principle stress in radial direction
σ_n	Nominal stress in reduced cross-section
σ_∞	Far-field stress
σ_y	Yield stress by 0.2% offset method

ACKNOWLEDGEMENT

I would like to thank all the people who assisted me in my education at the Naval Postgraduate School.

In particular, I would like to thank Professor G. H. Lindsey for his guidance in completing this work. I would also like to thank Professor G. Cantin for introducing me to the finite element method; Mr. Bob Besel and his staff for their support; and the staff of the W. R. Church Computer Center of the Naval Postgraduate School for their assistance.

I thank my wife and family for their sacrifices while I have been in pursuit of my career.

I. INTRODUCTION

Development of on-board fatigue monitoring systems for Naval aircraft have made it possible to record extensive structural loading data in flight. The strain gages used in such a system must be located away from stress concentration areas to prevent their fatigue; however, these areas are of the greatest interest in analyzing and predicting fatigue life of the structure. Understanding the relationship between nominal, far-field stresses and local stresses in critical areas thus becomes vitally important. Recent experimental investigations into the effect of uniform, far-field loads on stress concentration areas have been made at the Naval Postgraduate School (NPS) using photoelastic techniques [Refs. 1, 2 and 3]. These experiments involved loading 7075-T6 aluminum into both the elastic and plastic regions, as well as measurements of residual stresses resulting from plastic yielding.

Finite element analyses (FEA) of the aluminum panels used in the experiments of Stenstrom [Ref. 1] were conducted. The panels used in the experiments of Engle [Ref. 2] and Stuart [Ref. 3] have similar geometry. The finite element programs available at NPS were surveyed and ADINA [Ref. 4] was chosen for its proven ability to produce the nonlinear analyses required for plastic

yielding of aluminum. To provide increased accuracy, each panel was modeled using two meshes. The results obtained for the coarse and fine meshes were extrapolated to a final result using the Richardson extrapolation technique [Refs. 5 and 6].

Along with ADINA, a preprocessor program, PSAP1 [Ref. 7], was used to verify mesh connectivity prior to analysis by ADINA. PSAP1 provides a graphical output of the finite element mesh and was coded for the CALCOMP plotter installed at NPS prior to 1978. For this thesis PSAP1 was adapted for use with the VERSATEC plotter now installed at NPS.

The stress-strain material properties of the 7075-T6 aluminum actually used to make the panels had to be established to provide an accurate material model for use with ADINA. Material testing was conducted to establish the Young's Modulus (E), Poisson's Ratio (ν), yield stress (σ_y), strain hardening modulus (E_t) and the Ramberg-Osgood coefficients β and n.

Comparisons were made to other works, in addition to the experiments conducted at NPS. The initial analysis involved a comparison of FEA to the results of Howland [Ref. 8], for a circular hole in a finite strip, to validate the methods used. A comparison of FEA to plane stress, slip-line theory, for rigid-perfectly-plastic material was also included as a validation for the plastic analyses.

II. MATERIAL PROPERTY TESTING OF 7075-T6 ALUMINUM

The elastic and plastic material properties of the aluminum panels were established by tensile tests of uniaxial specimens made from the same mill run. The specimens were manufactured and tested according to current ASTM standards [Ref. 9]. MICRO-MEASUREMENTS, EA-13-125AD-120, precision strain gages with a temperature compensated bridge circuit were used on all specimens. Transverse gage sensitivity errors were corrected according to the manufacturer's recommendations [Ref. 10]. Critical cross-section measurements were made with a micrometer.

A. TESTS FOR AXIAL LOADING

Initial tests of the two-gaged specimen, Fig. 1, in the MTS testing machine indicated a significant bending moment was being produced by the 30,000 lb GRIFF grips. To investigate this problem further, tests were conducted on both the MTS and RIEHLE test machines with a five-gaged specimen shown in Fig. 2. The results of these axial loading tests, shown in Table I, verified that the GRIFF grips on the MTS test machine do not give axial loading. An inspection of the gripped region on the specimen indicated that the jaws of the grip were not applying a uniformly distributed force and thereby induced a bending

moment by off-axis loading as shown in Fig. 2. The grips on the RIEHLE test machine gripped evenly and a uniform strain distribution resulted as seen in Table I.

B. CHARACTERISTICS OF 7075-T6 ALUMINUM PANELS

The following characteristic properties were determined from the four specimens tested.

1. Young's Modulus (E)

Tests were conducted using the specimen shown in Fig. 3 on the MTS test machine with 10,000 lb INSTRON grips, which gripped the specimen evenly. The results of testing three specimens are shown in Tables II to IV. Linear regression in the elastic range of all the test results determined a Young's Modulus of 10.12×10^6 psi, with a correlation coefficient of 0.9996.

2. Poisson's Ratio (ν)

Tests were conducted using the specimen shown in Fig. 1 on the RIEHLE test machine with 10,000 lb RIEHLE grips. The results are tabulated in Table V. Linear regression of these results in the elastic region determined Poisson's Ratio to be 0.3256 with a correlation coefficient of 0.99996.

3. Yield Stress and Strain Hardening Modulus

These values, required for ADINA's bi-linear material model, were determined graphically using the data from Tables III and IV. Plastic region data in

Table II is not reliable because of excessive creep encountered during that test.

0.2% offset yield stress, σ_y = 76,000 psi

strain hardening modulus, E_t = 566,000 psi

The graphical fit of these values to the test data can be seen in Fig. 4.

4. Ramberg-Osgood Coefficients

The Ramberg-Osgood equation for elastic-plastic stress-strain characterization is given by:

$$\varepsilon = \frac{\sigma}{E} + \beta\left(\frac{\sigma}{E}\right)^n \tag{1}$$

where:

ε = strain

σ = stress

E = Young's modulus.

The β and n coefficients were determined graphically from the data of Table IV, by the method given by Rivello [Ref. 11]. The data in Table IV gave the following values which are the best fit to the combined test data

$\beta = 1.479 \times 10^{43}$

$n = 21.58$

The graphical fit of these values, in Eq. (1), with the test data is also shown in Fig. 4.

III. MODIFICATION TO GRAPHICAL PREPROCESSOR

The use of a graphical preprocessor program, such as PSAP1, is vital in detecting mesh errors that may otherwise go unnoticed. Establishing the proper node locations and element geometry prior to analysis for a complex code such as ADINA is of utmost importance.

A. PSAP1 MODIFICATIONS

The program PSAP1 was originally coded in FORTRAN IV for use on the NPS IBM 360/370 installation with the CALCOMP Model 765 drum plotter. The CALCOMP system once installed at NPS used the +Y axis as the unlimited plotting axis, see Fig. 5. The entire plotting logic in PSAP1 uses this orientation of axes to allow multiple plots in a continuous strip. With the VERSATEC Model 8222A electrostatic plotter now installed at NPS, the +X axis becomes the unlimited plotting axis, shown in Fig. 5. To avoid an extensive recoding of PSAP1 for use with the VERSATEC plotter, a simple coordinate transformation of the plot was made in a limited number of short subroutines. First, all installation dependent plotting calls used in PSAP1 were identified. These involved seven plotter functions for which new subroutines were coded.

Function	New Subroutine
Initialize Plotter	CALCMP
Move Plotter Pen	CALPLT
Letter on Plot	NOTATE
Number on Plot	CALNUM
Determine Current Pen Location	CALWH
Draw a Line	CALINE
Stop Plotter	PSTOP

The subroutines listed above merely rotates the plot to coincide with the VERSATEC axis orientation and retain all features originally in PSAP1. Since all plotter hardware code is now isolated in these seven subroutines, future adaptations to other plotting systems is simplified. To provide documentation of this update to PSAP1, a complete listing of the new program is provided in Appendix D.

B. USE OF PSAP1

Previous use of PSAP1 on the IBM 360 system necessitated use of a load module since PSAP1 took over one minute of CPU time to compile. With the new IBM 3033 system compilation requires eight seconds; however, use of a load module or disk stored source code is still recommended since PSAP1 contains roughly 2,500 lines of code. Appendix A contains sample JCL to use PSAP1 on the IBM 3033 MVS system. With minimal effort PSAP1 could also be set up

for use on the IBM VM/370 system. The user's manual for PSAP1 is in Ref. 7. In addition to a mesh plot, PSAP1 provides a listing of the node coordinates, element connectivity and several key input values used in execution of ADINA. This information provides a useful check of the input data.

IV. FINITE ELEMENT ANALYSIS (FEA)

A. DESCRIPTION OF MESHES USED

1. Length to Width Ratios and Boundary Conditions

Initial finite element models of specimens had length to width ratios near one, as used by Garske [Ref. 12] for his FEA, but they did not provide the desired uniform distribution at the loading boundary. Specimen length to width ratios of 3-5 were used by Armen, Pifko and Levine [Ref. 13] in their FEA and by Stenstrom [Ref. 1] in his photoelastic experiments. The criteria established to determine uniform boundary stress distribution was uniformity in nodal displacements along the loaded edge as discussed by Segerlind [Ref. 14]. In the models used for FEA in this thesis, nodal displacements were uniform to within 0.1%, and the resulting stress distribution was uniform axially to within 0.1% at the panel ends. In all cases two-dimensional, eight noded, isoparametric elements were used. These higher order elements cannot be loaded in an "intuitive" manner as discussed by Zienkiewicz [Ref. 15, p. 223]. Figure 6 shows the nodal loading required to obtain a uniform surface load.

2. Element Meshes

Two meshes were developed for each panel analyzed. A reasonable effort was made to keep element corner angles as close to 90° as possible to reduce the effect of element distortion discussed by Hopkins and Gifford [Ref. 16]. All meshes modeled a quarter of the actual panel by using the two axes of symmetry as is common practice in FEA. The step from course to fine element meshes was made so that each element in the course mesh was subdivided into four smaller elements of the same type. Such a mesh subdivision can be expected to give monotonic convergence of results, Cook [Ref. 17], and allow extrapolation to results of an infinitely fine mesh. Figures 7 through 13 illustrate the element meshes used in this analysis as plotted by PSAP1.

B. COMPUTATIONAL PROCEDURES

1. Using ADINA

Once the mesh has been developed, input data is prepared in accordance with the ADINA user's manual [Ref. 4]. This same set of data is then used as input for PSAP1 to check for errors and provide a graphical display of the element mesh. After preprocessing by PSAP1, the data is entered into ADINA for analysis. In the case of linear analysis, two types of stress output may be specified, nodal point or Gauss integration point. Nodal point output

can be computed for up to eight node point stresses for each element. Since 2x2 Gauss integration was used, four Gauss point stresses were computed for each element. The 2x2 Gauss integration is recognized as the most efficient integration order for this type of analysis [Ref. 15, p. 284]. The linear analysis used an isotropic linear elastic material model (MODEL "1" in Ref. 4) which required input of E and ν material properties. The nonlinear analysis allows only Gauss point stress outputs and uses a bilinear elastic-plastic material model, with von Mises yield condition and isotropic strain hardening (MODEL "8" in Ref. 4).

For static analyses ADINA uses a time function method to apply loads in steps. Linear analysis loading was accomplished in a single step to a nominal value of 3,000 lbs load. Nonlinear analysis loads were applied in ten steps to a maximum value, matching the experimental loads, and then unloaded to zero in ten steps to obtain residual stresses. The stress output from ADINA is a listing of nodal or Gauss point stresses for each element. Since the only area of interest in this analysis was the distribution of stresses along the reduced cross-section, no large post-processing program was developed or used. All final computations using ADINA output data were accomplished on a HEWLETT-PACKARD 9830A calculator, using short programs coded in BASIC. If more extensive stress

distribution information were desired, some form of automated post-processing would be necessary to reduce the computational workload. At a minimum, nodal stress outputs by ADINA must be averaged to obtain unique values of stress at nodes shared by more than one element.

2. Richardson Extrapolation

The use of course and fine meshes allows extrapolation to an infinitely fine mesh as discussed earlier. Richardson extrapolation [Ref. 5] was used in this analysis where:

$$\sigma_{extrap} = \frac{\sigma_C (h_F)^m - \sigma_F (h_C)^m}{h_F^m - h_C^m} \tag{2}$$

where

σ_{extrap} = extrapolated solution

σ_C = solution obtained with $h=h_C$

σ_F = solution obtained with $h=h_F$

h_C = linear dimension of course element

h_F = linear dimension of fine element

m = 2 (for this analysis)

The exponent m is determined by the order of the discretization error $O(h^m)$. Since h represents the length of an element the element area is represented h^2. In a two dimensional problem such as this $O(h^m)$ is of the order of h^2, the area of an element. In the mesh refinement scheme

used $h_F = \frac{1}{2} h_c$ or $\frac{h_F}{h_c} = \frac{1}{2}$. Equation (2) can be rewritten

$$\sigma_{extrap} = \frac{\sigma_c (\frac{h_F}{h_c})^2 - \sigma_F (\frac{h_c}{h_c})^2}{(\frac{h_F}{h_c})^2 - (\frac{h_c}{h_c})^2} \tag{3}$$

thus

$$\sigma_{extrap} = \frac{\sigma_F - \frac{1}{4} \sigma_c}{\frac{3}{4}} \tag{4}$$

Equation (4) then becomes the relation to obtain extrapolated stresses from coarse and fine mesh results in a two dimensional analysis. Better extrapolations can be obtained by using three or more refined meshes, but the computational effort increases significantly.

3. Optimal Stress Locations and Local Smoothing

It is generally accepted that the most accurate sampling points for stresses are the Gauss integration points within the element [Ref. 15, p. 281, and Ref 18]. In this analysis, the nodal points are of the greatest interest; thus a technique of local smoothing must be applied to the integration point stresses to obtain nodal stresses as reported by Hinton and Campbell [Ref. 19]. The formulation of this local smoothing technique for ADINA elements is developed in Appendix B. The nodal values obtained must then be averaged if shared by two or more elements.

4. Computational Times

Because of the extremely large size of ADINA (about 17,000 lines of code in the NPS version) and the out of core solver, it does not adapt well to time sharing systems. Using the IBM 360 system at NPS, ADINA required 31 user defined overlays to create a manageable load module in about 30 minutes of CPU time. With the new IBM 3033 MVS system at NPS, ADINA is compiled without overlays in about one minute. When using a load module, the program execution took less than 2 minutes CPU time on the IBM 3033.

In addition to ADINA, the preprocessor (PSAP1) and post-processing techniques involve considerable time and effort. Figure 14 is a flow chart of the computational procedure used in this analysis. An example of the JCL to use ADINA in load module form on the IBM 3033 MVS system with use of the mass storage facilities is shown in Appendix C.

V. RESULTS OF ANALYSIS

A. CIRCULAR HOLES IN LINEAR MATERIAL

The FEA results for a circular hole in a finite width strip were used to validate the elastic computational procedure discussed earlier. The results of Howland [Ref. 8] were compared to both the Gauss point smoothed results and the nodal output results in Fig. 15. The stress concentration factor σ/σ_∞ is referenced to the far-field stress. The smoothed results give the best match to the results of Howland at the edge of the hole, and the only significant variation between the two FEA methods occurs within the first 0.25 inches from the edge. In order to obtain the 0.25 inch stress value for the coarse mesh, in the Gauss point smoothed result, a midside node value had to be obtained by the averaging method discussed in Appendix B. The linear distribution of smoothed stresses along the sides of the element, [Ref. 19], appears to produce a less accurate result in this area of extreme stress gradient, when compared to ADINA's nodal output result. This tendency was noted in all cases; however, the peak stress values from smoothed results consistently gave better correlation with other investigators [Ref. 20].

A circular hole with $\lambda=0.25$ was also analyzed and compared to the experimental results of Stenstrom [Ref. 1]

along with an interpolation of Howland's results. The σ_θ experimental data correlates well with the FEA results; however, the σ_r experimental data shows significant variation between 0.125 and 0.375 inches from the edge of the hole, as seen in Fig. 16.

B. OPPOSITE U NOTCHES IN LINEAR MATERIAL

The results for linear analysis are presented in non-dimensional stress concentration form; however, the normalizing stress changes. For U notches K_T is the stress concentration factor referenced to the theoretical, nominal stress (σ_n) in the reduced cross-section where σ_n = Load/Area of Reduced Cross-Section.

1. Shallow Notch Panel

The FEA results plotted with the experimental data of Stenstrom are shown in Fig. 17. Once again both FEA results are shown and the variation for the two methods occur within 0.25 inches from the notch edge; however, there was less variation than was seen in the circular hole analyses.

For this panel the experimental data appear to be uniformly below the FEA results for σ_θ. The σ_r data shows significant variation at the 0.625 inch point but follows the proper trend within 0.5 inches from the notch edge. According to data collected by Peterson [Ref. 20], this notch geometry should yield a maximum $K_T = 2.74$. The

Gauss point smoothed results matched this value exactly. Stuart [Ref. 3] reported a $K_T = 2.69$ for this same notch geometry, with a standard deviation of 0.187 in the 14 samples he measured by photoelastic methods. Early photoelastic work by Frocht [Ref. 21] determined $K_T = 2.7$ for this notch geometry. The FEA results appear to be in good agreement with other investigators, for this notch geometry.

2. Deep Notch Panel

Results of the FEA for a deep notch were plotted with Stenstrom's experimental data in Fig. 18. The results of the two FEA methods again diverge within 0.5 inches from the notch edge. FEA stress values at the 0.25 inch point have spread farther apart in this case since the stress gradient is very severe at that point. The experimental data correlates well for both σ_θ and σ_r; however, the maximum experimental σ_θ is considerably lower with a $K_T = 3.83$. Results reported by Stuart for this notch geometry was a $K_T = 4.05$ with a standard deviation of 0.219 for 14 specimens measured by photoelastic methods. Frocht [Ref. 22] reported a photoelastic $K_T = 3.9$ for this notch geometry, but concluded that the result was 5-10% low, giving a corrected range of K_T from 4.1 to 4.3. The Gauss smoothed FEA result gave a $K_T = 4.24$ which compares well to an empirical relation given by Peterson [Ref. 20] for $r/d < 0.25$.

$$K_T=(1-\frac{2t}{D})(0.78+2.243\sqrt{t/r})\left[0.993+0.18\frac{2t}{D}-1.06(\frac{2t}{D})^2+1.71(\frac{2t}{D})^3\right] \quad (5)$$

where

t = notch depth (3.9375)

r = notch radius (0.625)

d = minimum width (15.625)

D = maximum width (23.5)

Inserting the values above into Eq. (5) gives a K_T = 4.26, which is 1/2% above the FEA result. Other FEA results reported by Armen, Pifko and Levin [Ref. 13] and Griffis [Ref. 23], using linear strain triangle (LST) elements, produced K_T values within 5% of those produced by use of Eq. (5). The rectangular elements used in this analysis are known to give better results than LST elements as noted by Clough [Ref. 24]. It is clear that the FEA results obtained for this notch are in good agreement with other works.

C. OPPOSITE U NOTCHES IN NONLINEAR MATERIAL

The analysis for loading into the plastic region of the 7075-T6 aluminum was made using the bilinear material model discussed earlier. The loads used were selected to match those used in the experiments of Stenstrom; thus allowing direct comparison. The strains obtained in those experiments were used to solve for stresses by use of the Prandtl-Reuss plastic flow equations.

1. Shallow Notch Panel

The results of FEA for the three load cases, 60,000, 65,000 and 70,000 lbs are presented along with the experimental results in Figs. 19 through 21. The σ_θ results compare well although no trend for peak σ_θ stress away from the notch edge is shown in the experimental data. In all cases the FEA determined the peak σ_θ stress to occur near the yield boundary, and the gradient of the σ_θ stress to fall off dramatically in the plastic zone. This characteristic behavior of the σ_θ stress was reported by other investigators [Refs. 13 and 23] using FEA on 2024-T3 aluminum. Plane elastic-plastic stress distributions reported by Frocht [Ref. 25] show similar trends. The experimental data also shows a marked change in the gradient of σ_θ stress within the plastic region. The growth of this plastic region is approximated using the FEA results for this notch in Figs. 22 through 24.

Experimental data for the σ_r stress distribution matches the FEA results closely except at the notch edge where the measured σ_r does not go to zero as it should. The characteristic peak value of σ_r near the plastic boundary as seen in the FEA results is also shown by the test data.

The FEA residual stress computed upon unloading from the three load cases are shown in Figs. 25 through 30. The characteristic distributions of the σ_θ residual stress

agrees with those reported by others [Refs. 25, 26 and 27]. The experimental residual stress distributions reported by Stenstrom show similar trends but significant variations when compared to the FEA results.

2. Deep Notch Panel

Three load cases were computed to plastic loading levels; however, only limited experimental results are available for this notch as seen in Fig. 31. The 30,000 lb load is just at the onset of yield in the notch root area. Limited residual experimental data [Ref. 3] was available for comparison in Figs. 32 and 33 which are plots of the residual σ_θ and σ_r stress distributions as a result of the three loading cases. The 30,000 lb load has caused yielding in a small region at the root of the notch as seen in Fig. 34. Figures 35 and 36 illustrate that the plastic zone does not grow to the extent it did in the shallow notch. The stress gradients are very severe in the deep notch and as a result the 0.25 inch sampling points used in the FEA may be useful in only showing gross trends close to the notch edge. The trends appear to be much the same as in the shallow notch, with the peak σ_θ and σ_r stresses occurring near the yield boundary. The yield boundaries shown in Fig. 31 are approximations based on qualitative analysis of the finite element results. The σ_θ experimental data for the 30,000 lb load case correlates well with the peak stress, again

appearing low as it did in the linear analysis. The residual σ_θ stress distribution in Fig. 32 follow much the same trends as seen in the shallow notch but with much higher gradients within the first 0.5 inches from the notch. The FEA results for the residual σ_r stresses shown in Fig. 33 indicate a limitation in the element size used since the σ_r value of the notch edge does not return to zero as it should. Because of this problem the data may be questionable for showing proper trends in the first 0.5 inch from the notch edge.

3. Rigid-Perfectly Plastic Panel

A stress distribution for the theoretical material used in slip-line theory was desired. By using ADINA's bilinear material model such a material could be approximated reasonably well. For this analysis a Young's Modulus (E) of 10^{26} psi was used to model perfect rigidity. The strain hardening modulus (E_t) was set to zero to model perfect plasticity. Poisson's ratio (ν) was 0.4999999, as close to 0.5 as the computer would allow. The $E = 10^{26}$ also represents a computer limit in approaching an infinitely large E. Figure 37 illustrates the results obtained and compares them to a slip-line solution. The results are normalized to the arbitrary 73,000 psi yield stress used in the analysis. The σ_θ values obtained agree exactly with slip-line theory. Conversely the σ_r results do not reflect the same values as slip-line theory, but do show

a similar trend. The growth of the plastic zone obtained is shown in Figs. 38 through 40.

VI. CONCLUSIONS AND RECOMMENDATIONS

The results obtained from the FEA have proven useful in determining the validity of experimental data gathered by photoelastic techniques. The FEA results varied by less than 1% when compared to published analytical results and handbook values. Experimental data from Stenstrom's photoelastic work correlated well with the FEA results. The primary exception was the residual stress experimental values, which varied significantly from the FEA results. The variation may be in transforming the residual strains measured photoelastically into stresses for comparison with the FEA results, since ADINA only provides a stress output. Limitations of ADINA's bilinear material model, initially considered severe, do not appear to have hampered this investigation. A possible exception is the residual analyses where the transition region from elastic to plastic strains becomes especially important. The Gauss point smoothed results gave the best correlations at the edge singularities in all cases; however, due to the limitations noted at 0.25 inches from the edge, the results at that specific point may not be as accurate for this method. The nodal output results gave consistently higher stress values at the edge singularities. Because

of the severe stress gradients near the deep notch analyzed the use of a finer element mesh near the notch would probably produce better results.

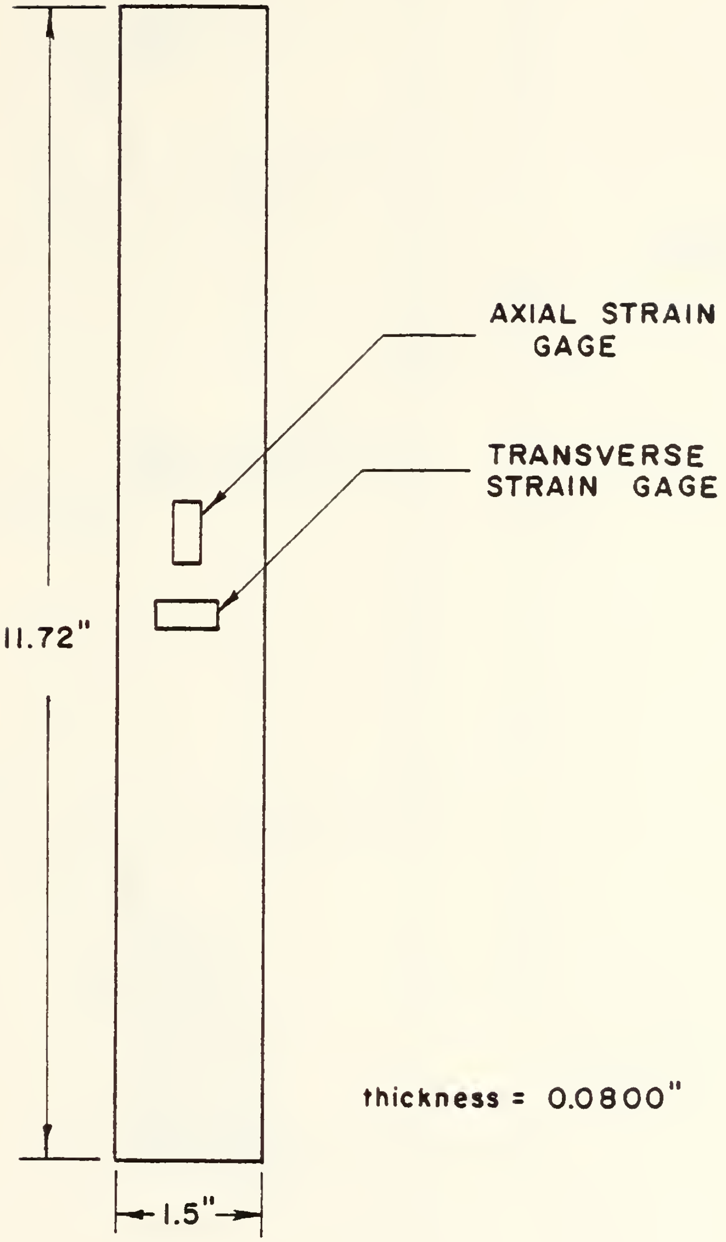
The effort involved in developing two meshes such as those used in this thesis is considerable. An automatic mesh generation capability would reduce the workload and allow experimentation with several types of element meshes.

ADINA proved to be a useful and powerful program, as expected, but something simpler and less awkward to use may be all that is required for two dimensional analysis. Such a system is already in use at NPS but does not offer non-linear capabilities. If use of ADINA is to be continued in this type of investigation, a post-processing program should be adapted. There are programs available to post-process ADINA data at NPS [Refs. 28 and 29] but they would require modifications to work with two dimensional analyses and the VERSATEC plotter.

Standardized material property testing would ease the inevitable task of obtaining basic material properties for use in analysis or experiments. Some form of automatic data collection with use of the MTS testing machine would allow testing of a larger sample population and provide statistically more accurate information.

FIGURE 1

2 GAGE SPECIMEN



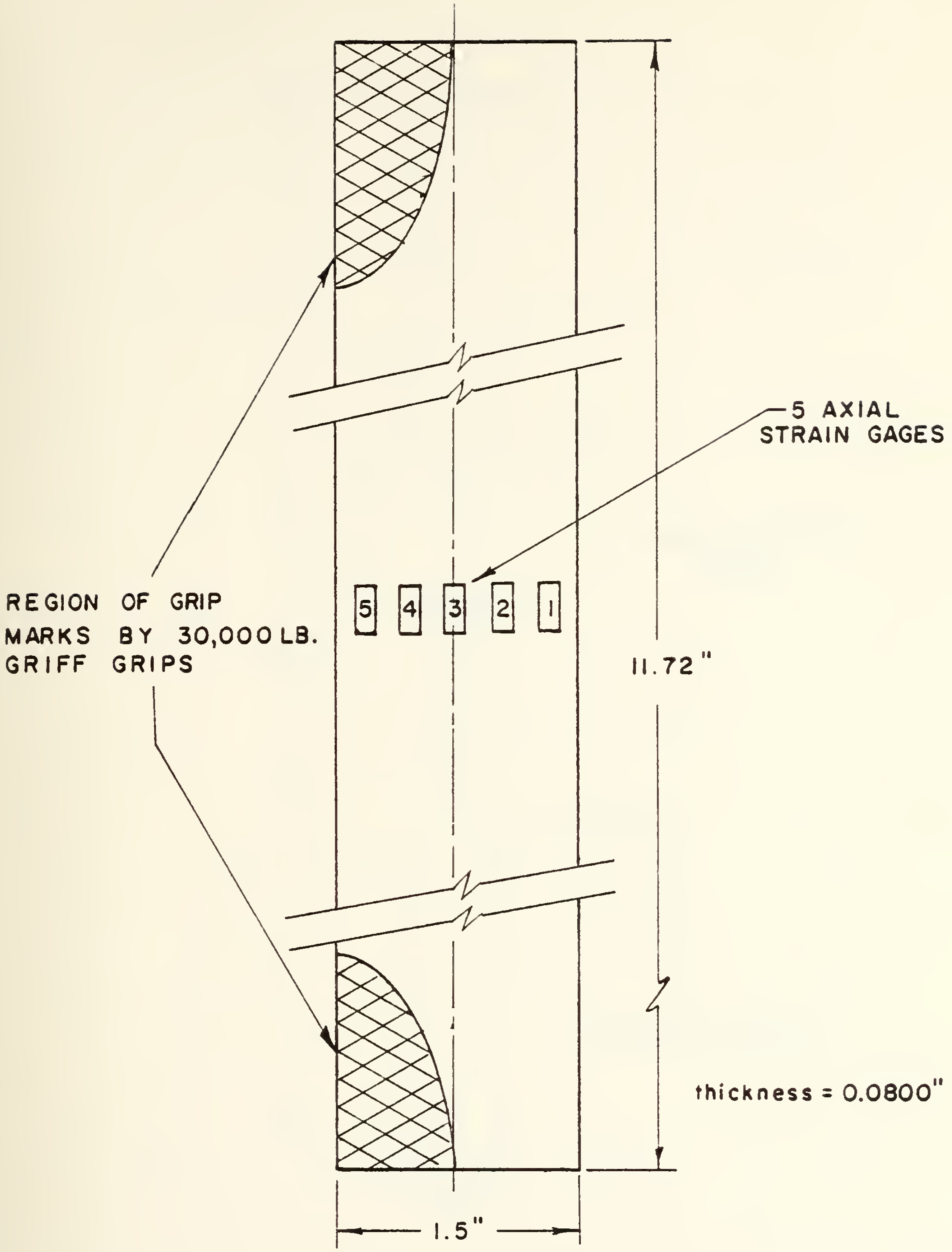


FIGURE 2

5 GAGE SPECIMEN

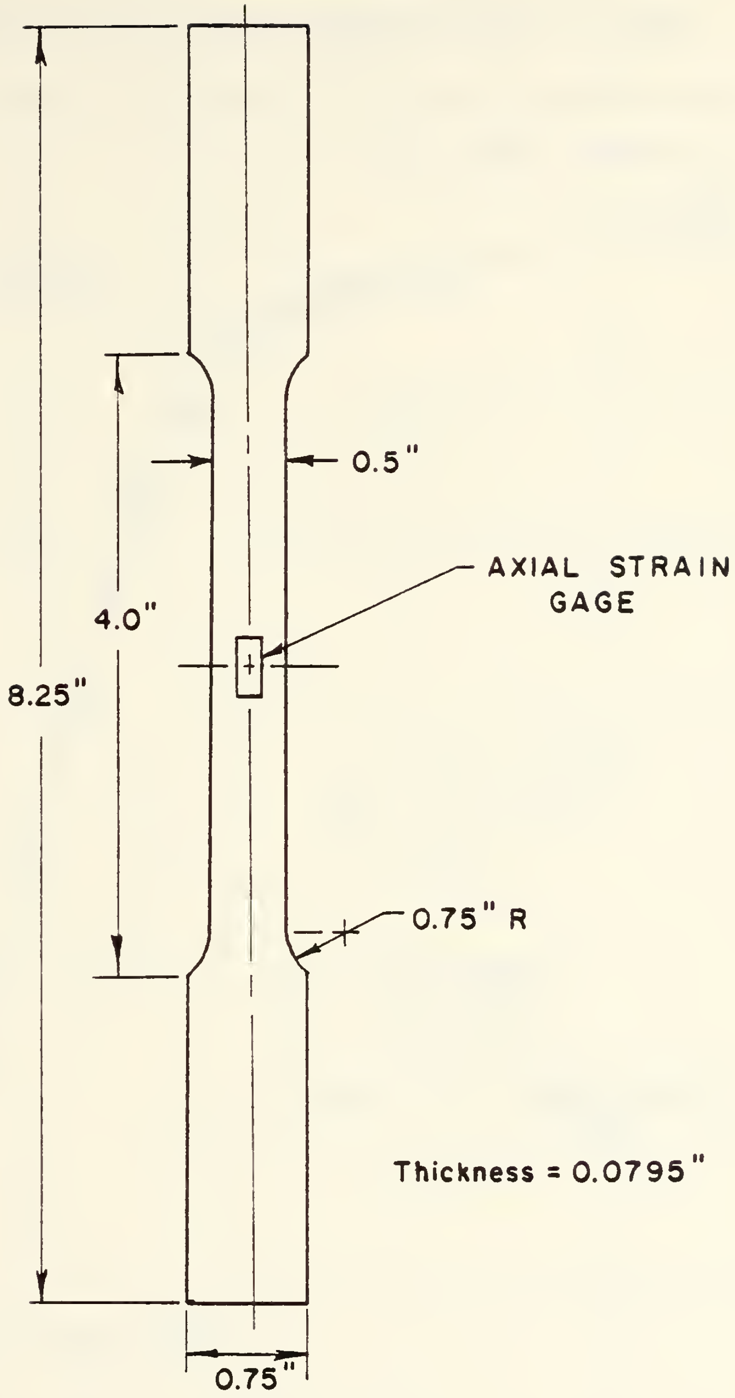
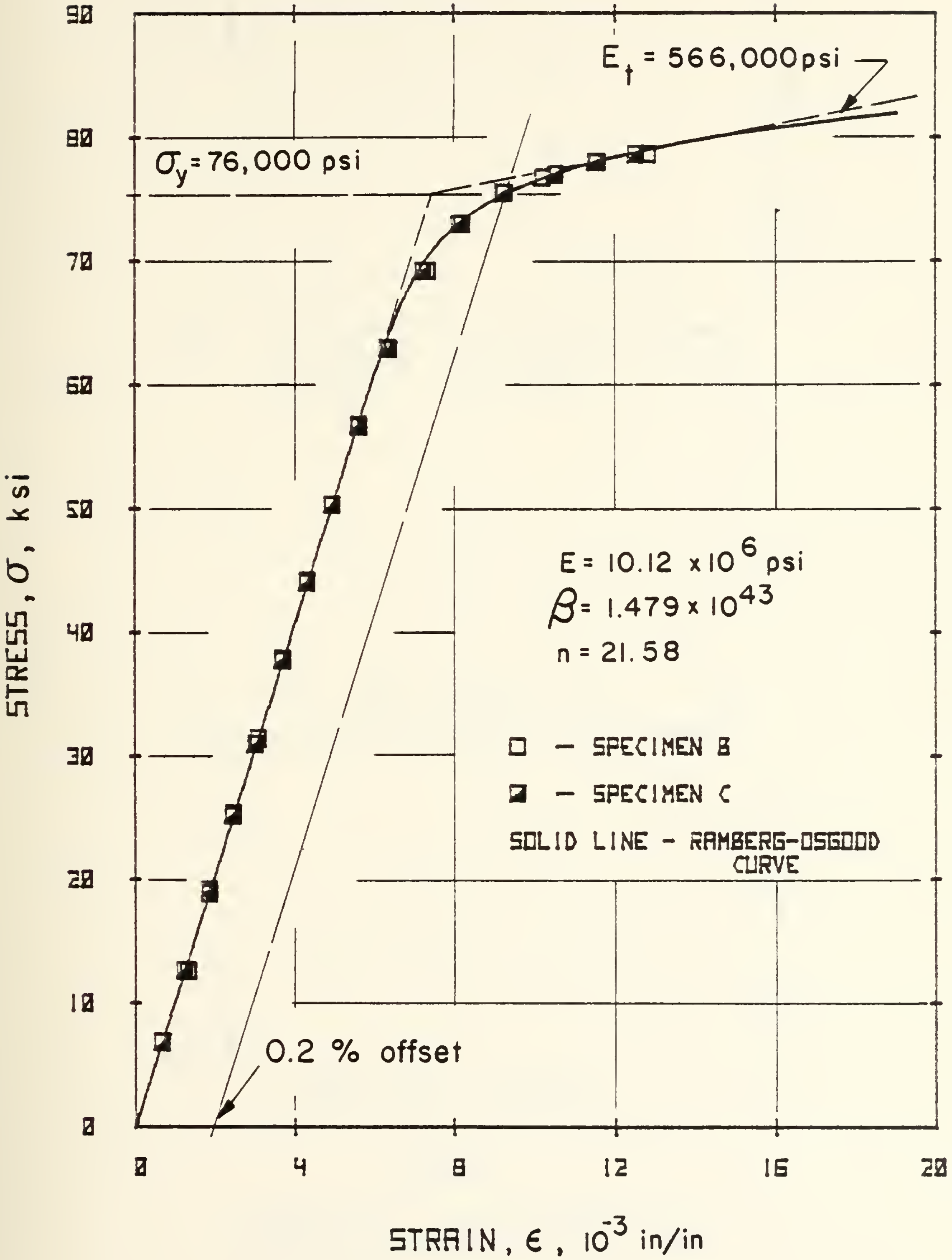


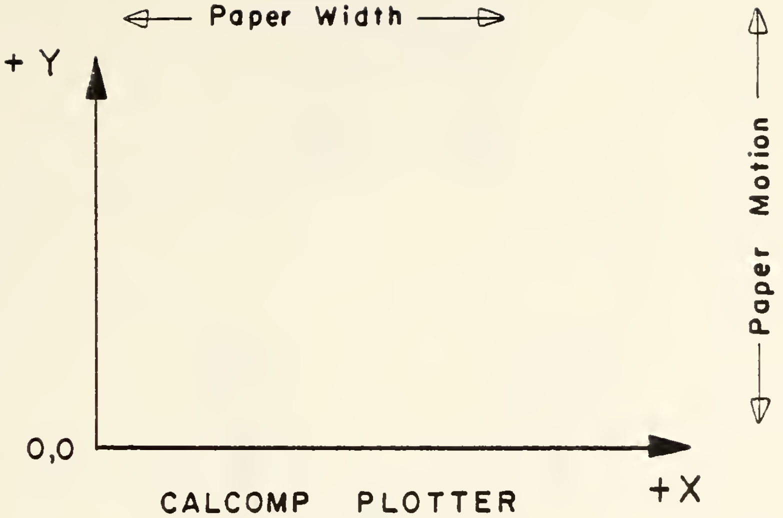
FIGURE 3

1 GAGE SPECIMEN

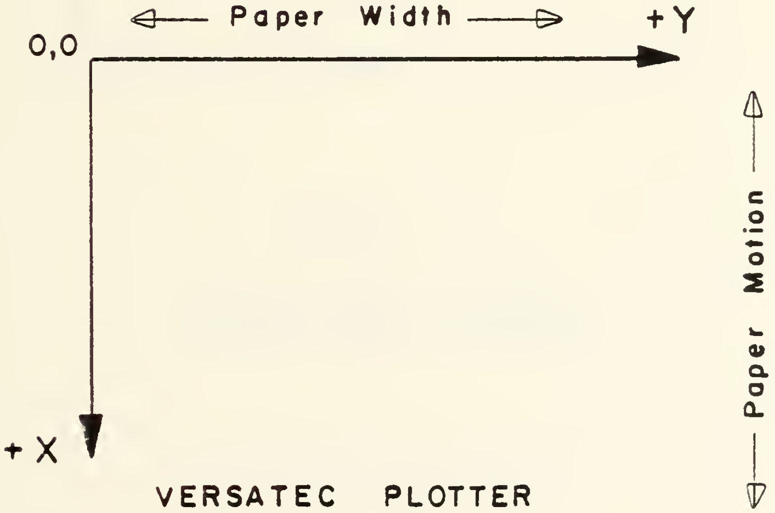
FIGURE 4

7075-T6 ALUMINUM STRESS-STRAIN CURVE





CALCOMP PLOTTER



VERSATEC PLOTTER

FIGURE 5

CALCOMP AND VERSATEC PLOTTER AXES

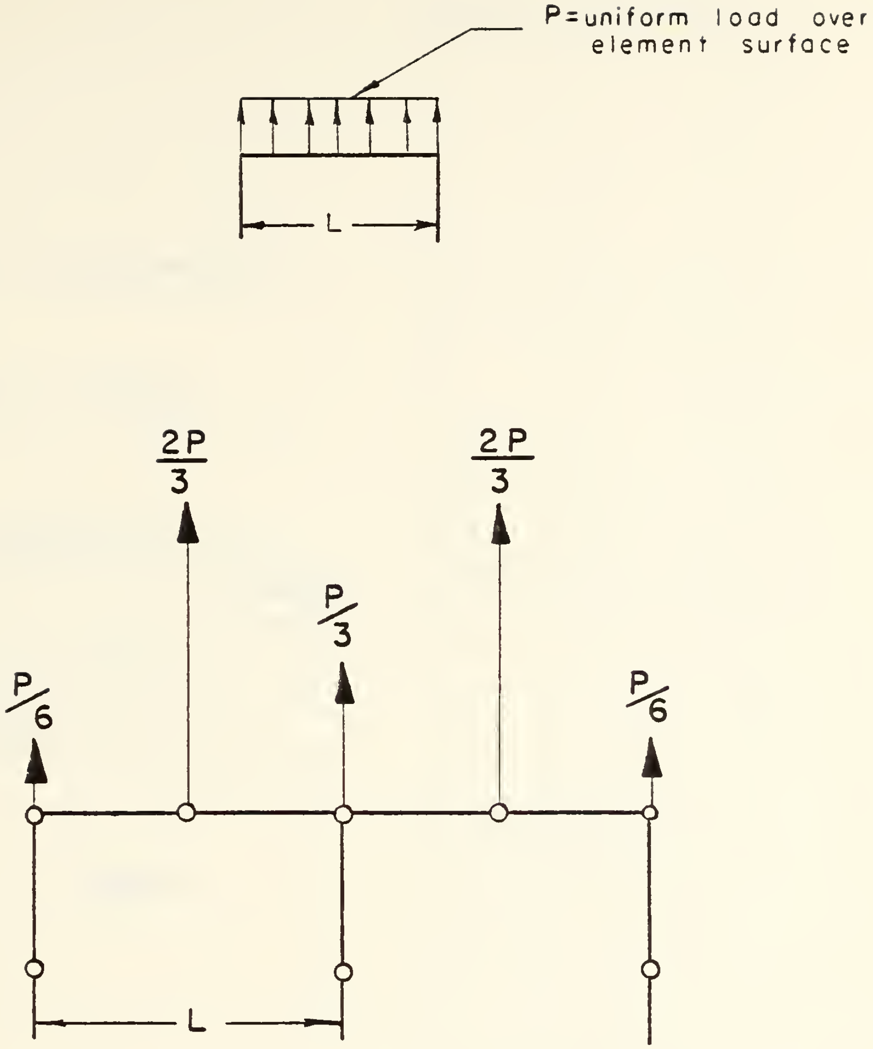


FIGURE 6

NODAL LOADING DIAGRAM

28 ELEMENTS (ISOPARAMETRIC)

111 NODES

192 DEGREES OF FREEDOM

DIMENSIONS

λ	W	L	RADIUS
0.2	5"	25"	1"
0.25	4.0625"	20"	1"

$$\lambda = \frac{\text{RADIUS}}{W}$$

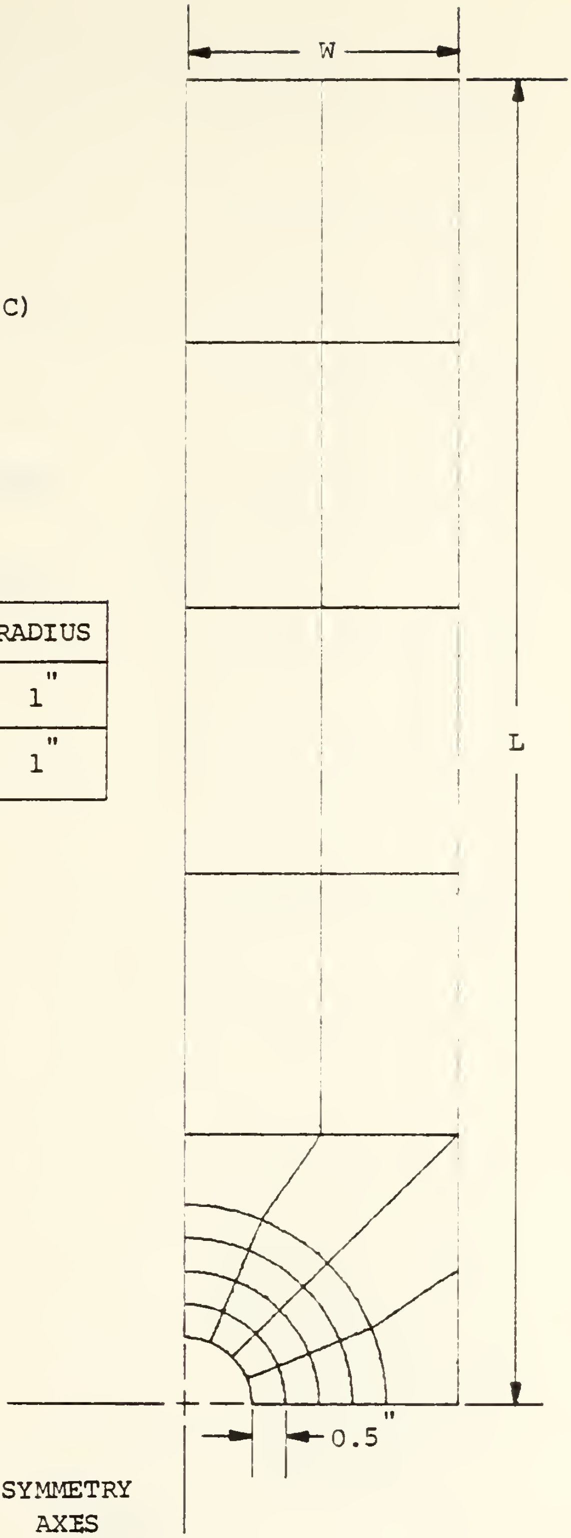
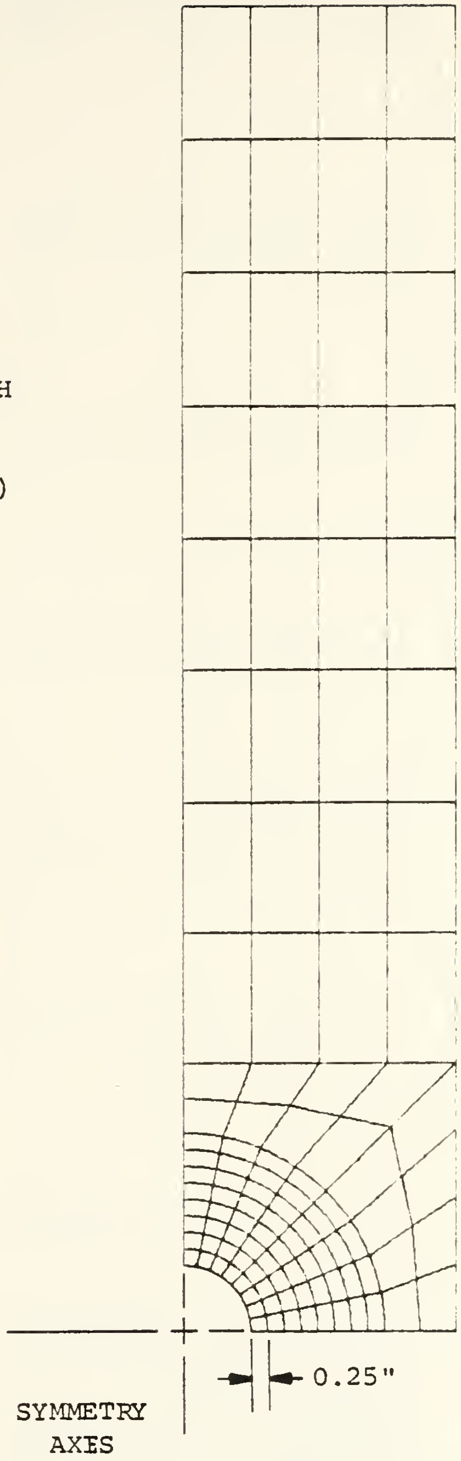


FIGURE 7

COURSE MESH FOR CIRCULAR HOLES



A SUBDIVISION OF COURSE MESH

112 ELEMENTS (ISOPARAMETRIC)

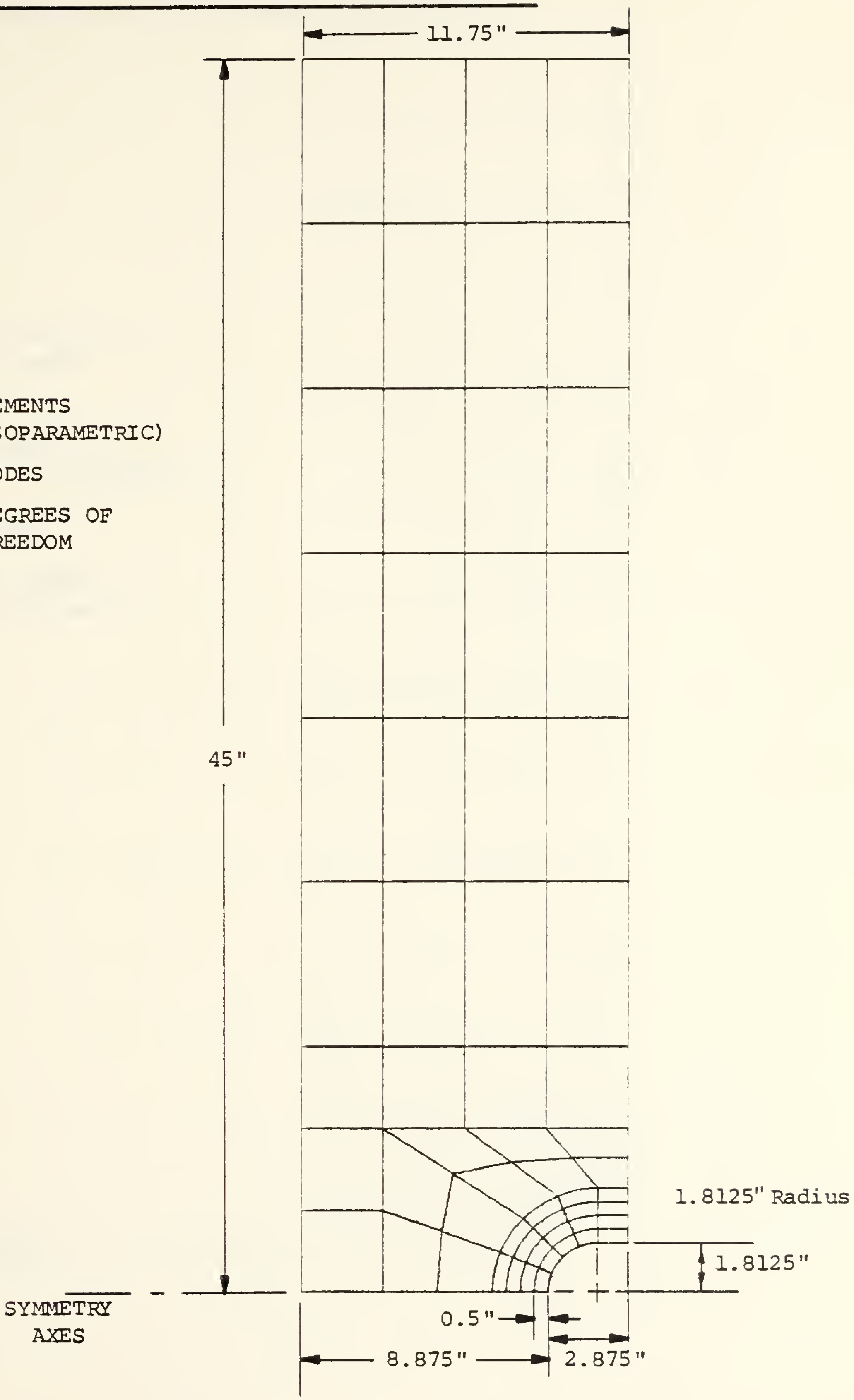
389 NODES

720 DEGREES OF FREEDOM

FIGURE 8

FINE MESH FOR CIRCULAR HOLES

FIGURE 9 COURSE MESH FOR SHALLOW NOTCH

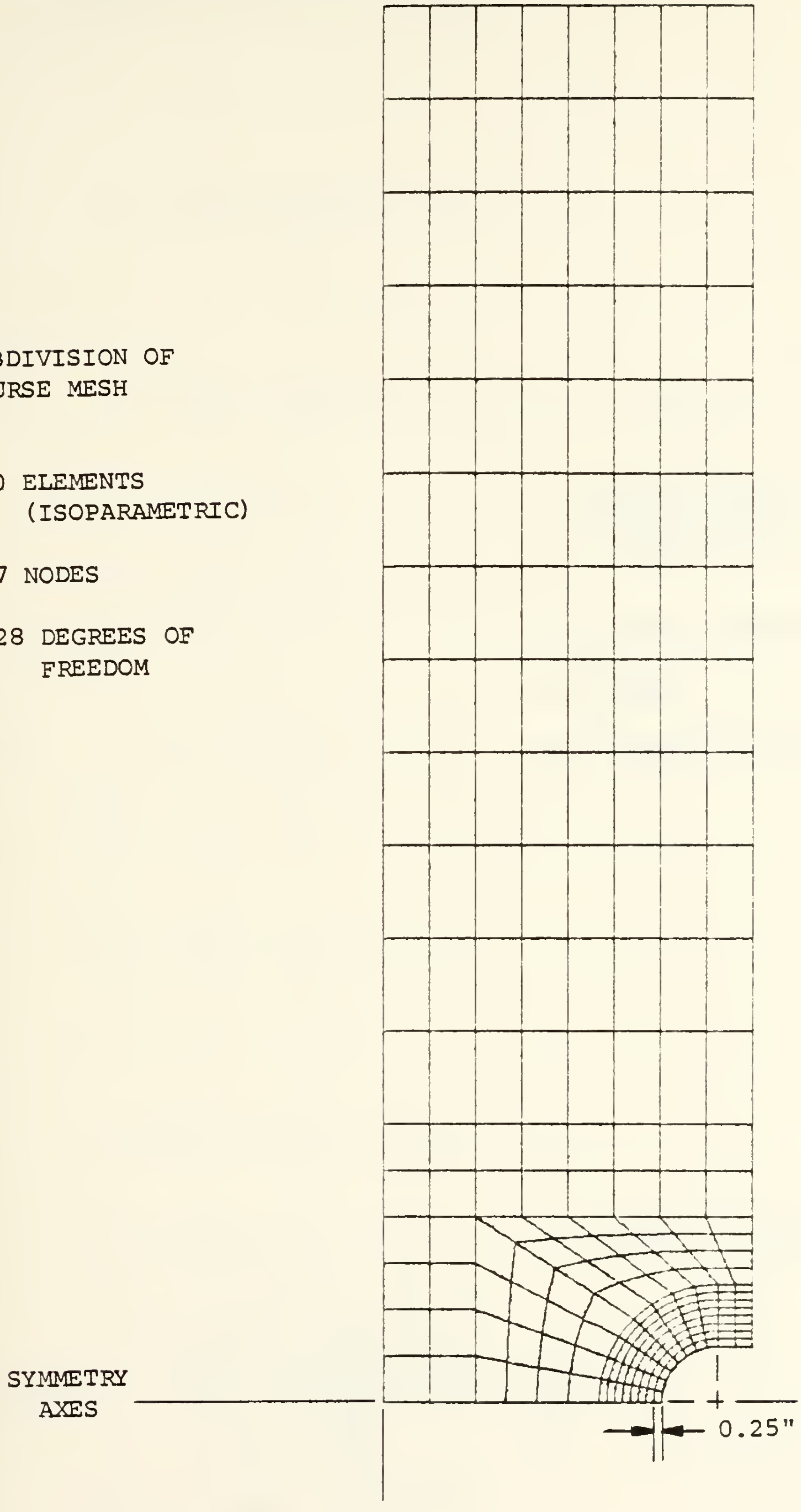


60 ELEMENTS (ISOPARAMETRIC)

219 NODES

404 DEGREES OF FREEDOM

FIGURE 10 FINE MESH FOR SHALLOW NOTCH



SUBDIVISION OF
COURSE MESH

240 ELEMENTS
(ISOPARAMETRIC)

797 NODES

1528 DEGREES OF
FREEDOM

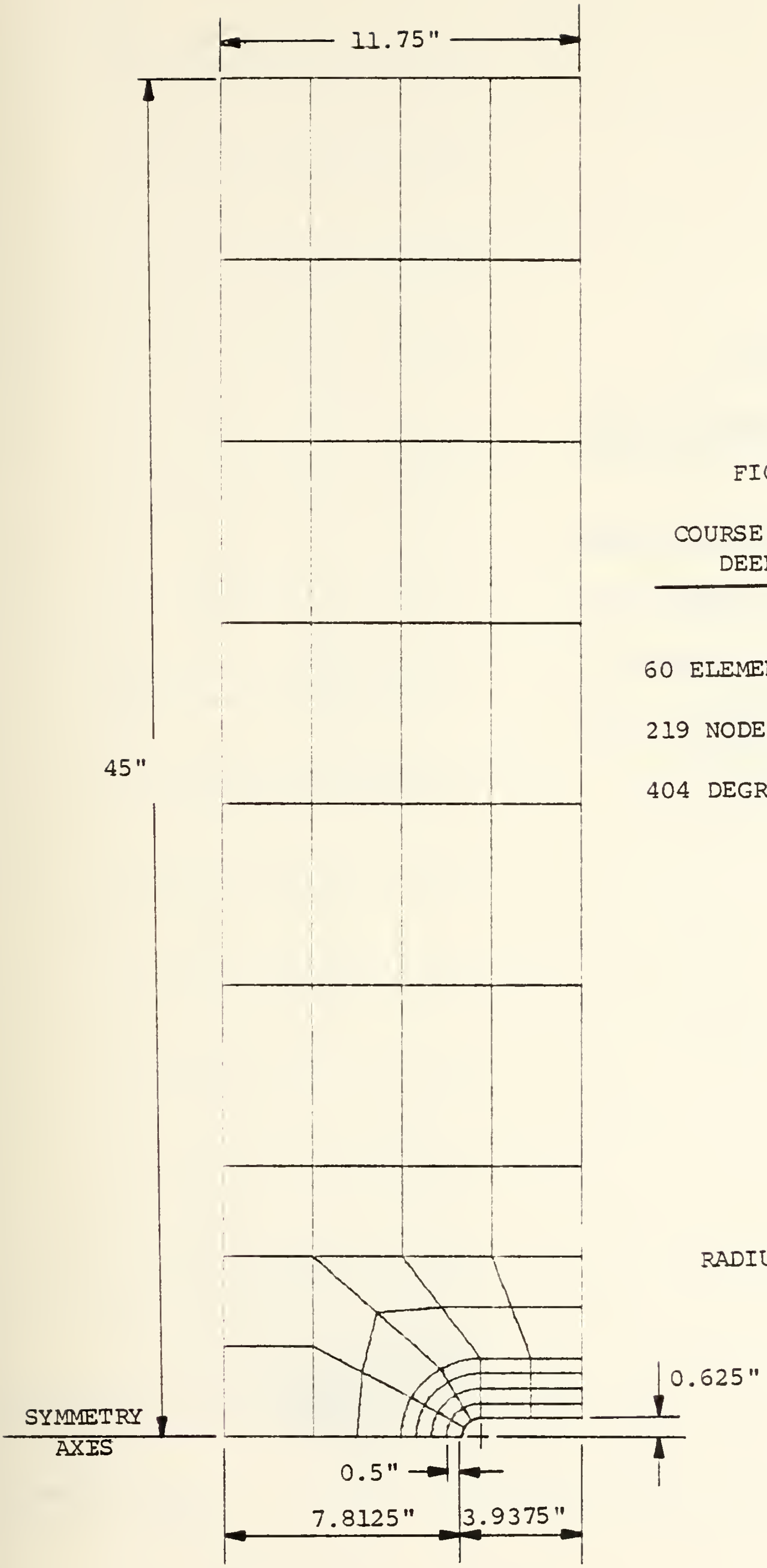


FIGURE 11

COURSE MESH FOR DEEP NOTCH

60 ELEMENTS (ISOPARAMETRIC)

219 NODES

404 DEGREES OF FREEDOM

RADIUS OF NOTCH= 0.625"

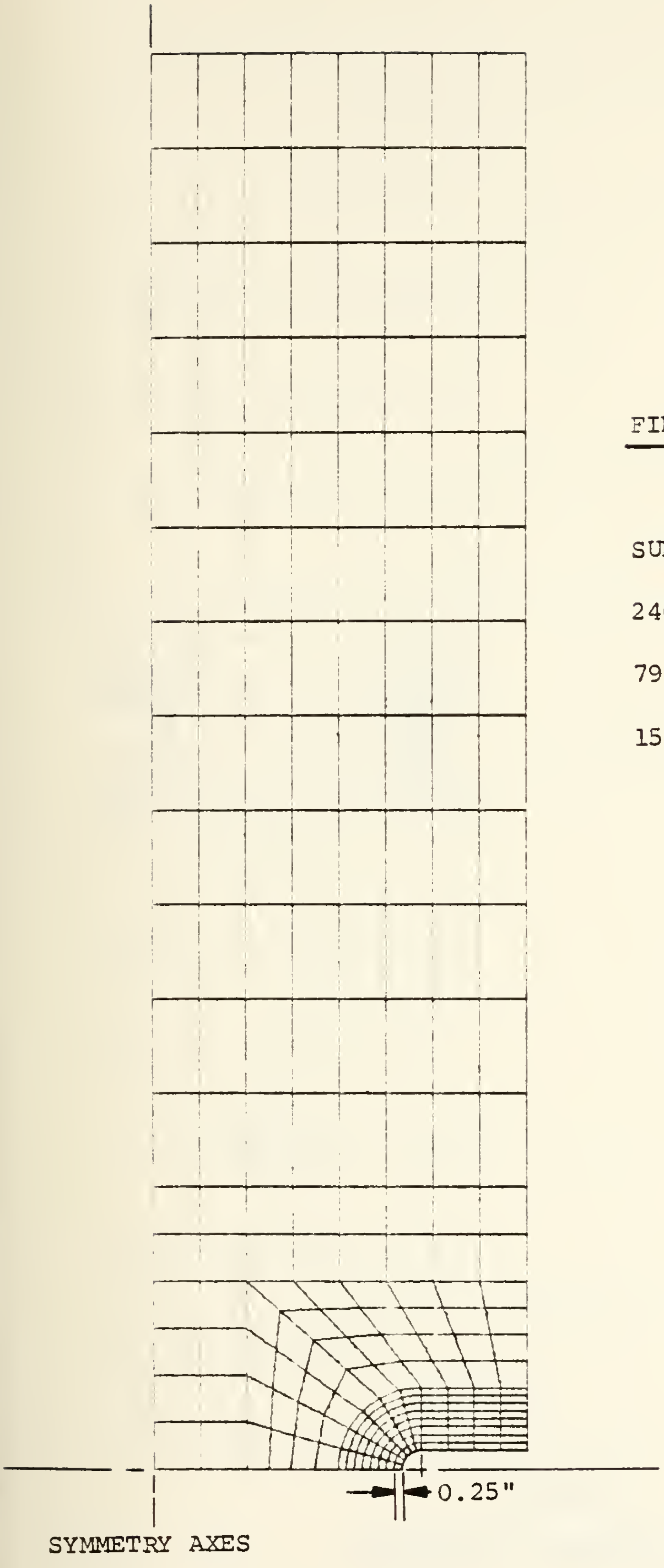


FIGURE 12

FINE MESH FOR DEEP NOTCH

SUBDIVISION OF COURSE MESH

240 ELEMENTS (ISOPARAMETRIC)

797 NODES

1528 DEGREES OF FREEDOM

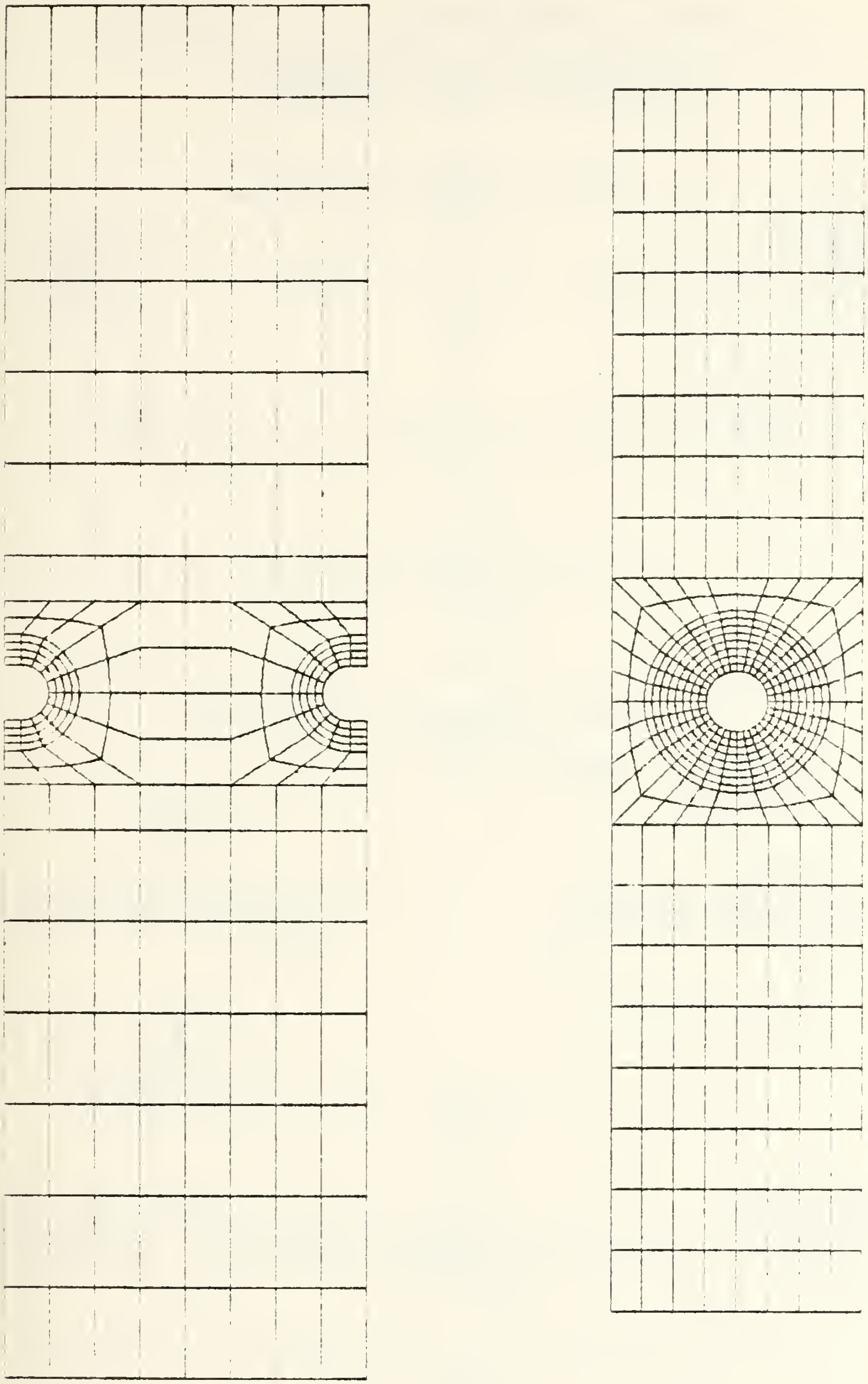


FIGURE 13

EXAMPLE OF COMPLETE PANEL MESHES

FIGURE 14 COMPUTATIONAL FLOW CHART

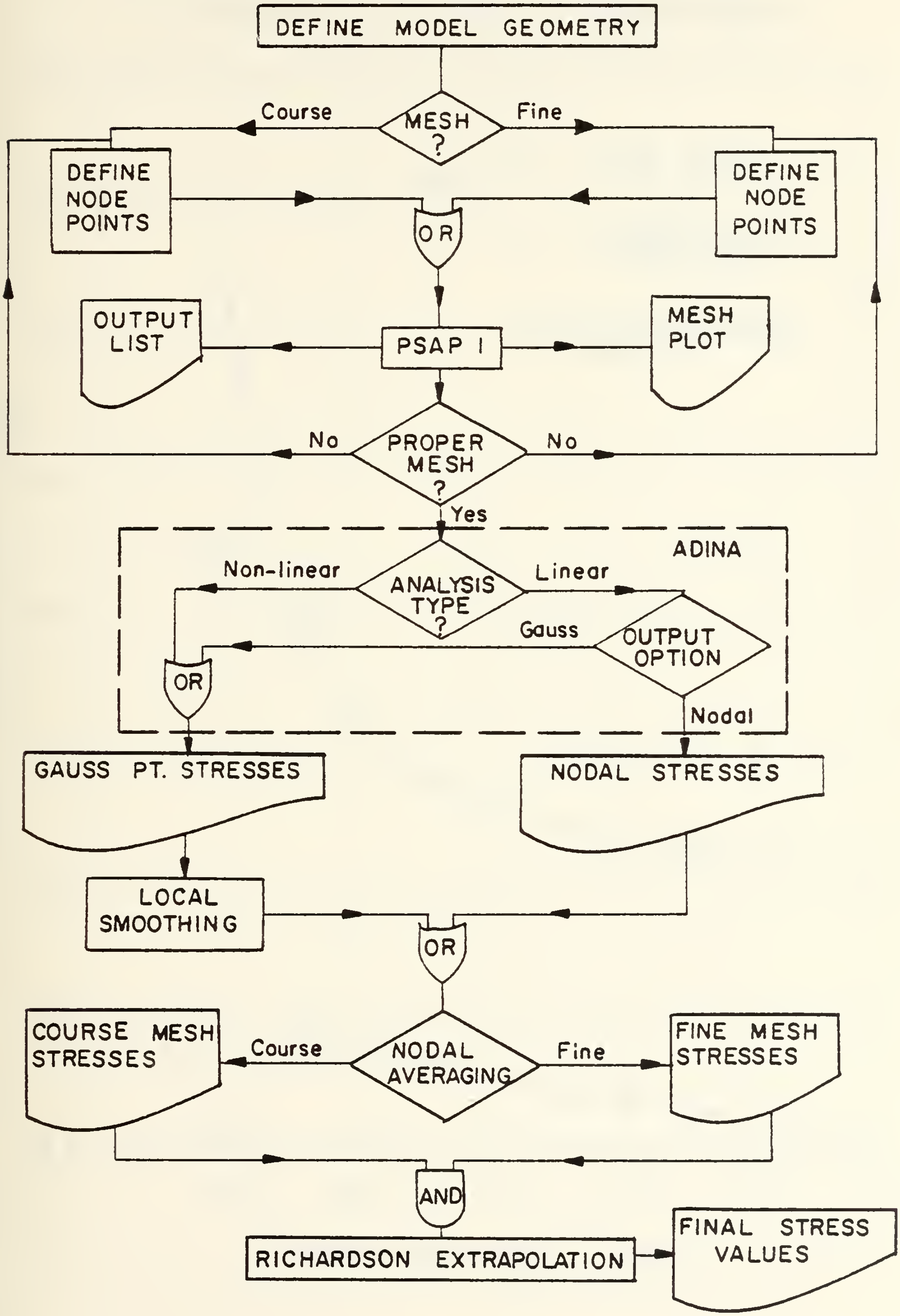


FIGURE 15

CIRCULAR HOLE $\lambda=0.2$ LINEAR RESULTS

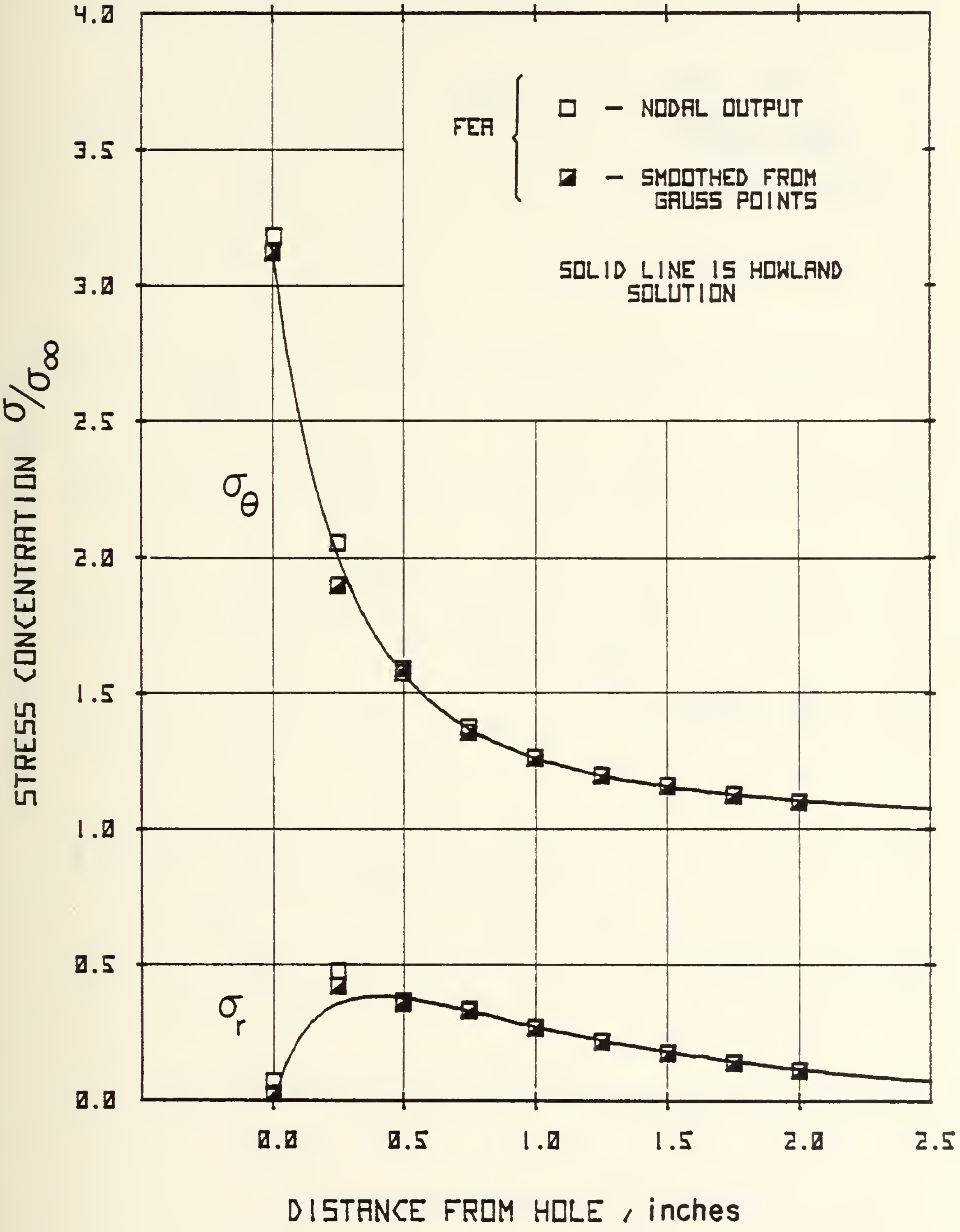


FIGURE 16

CIRCULAR HOLE $\lambda=0.25$ LINEAR RESULTS

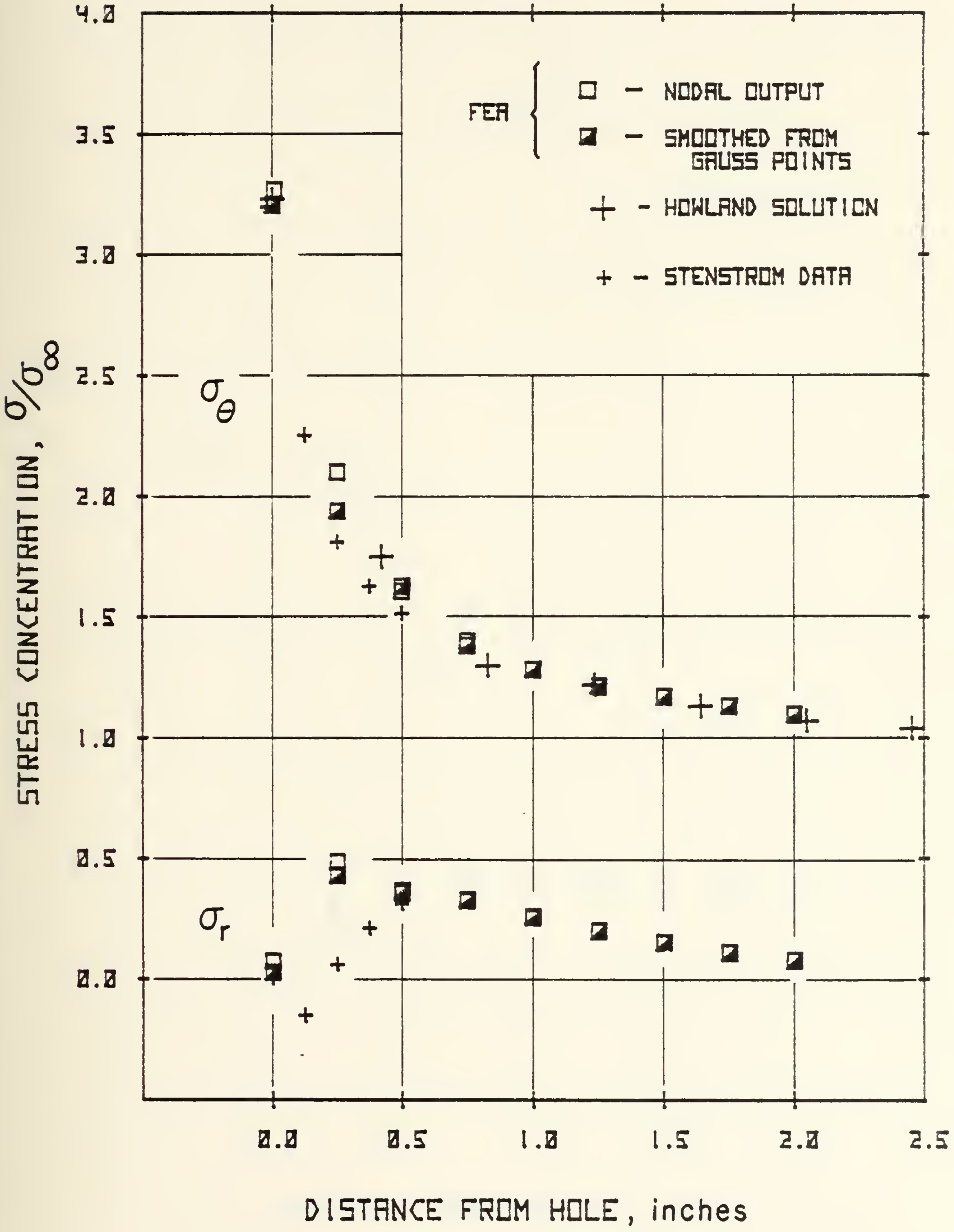


FIGURE 17

SHALLOW NOTCH LINEAR RESULTS

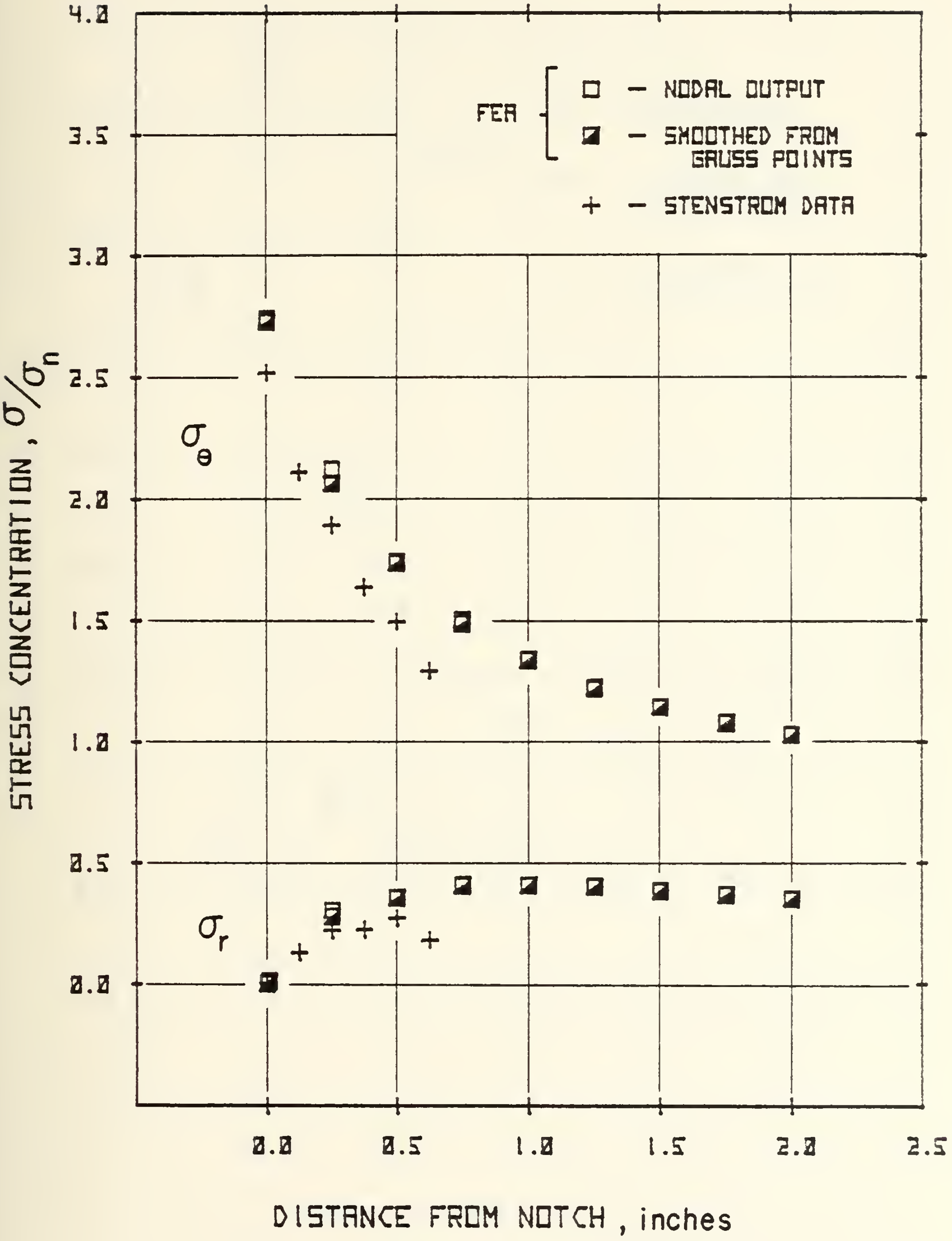


FIGURE 18

DEEP NOTCH LINEAR RESULTS

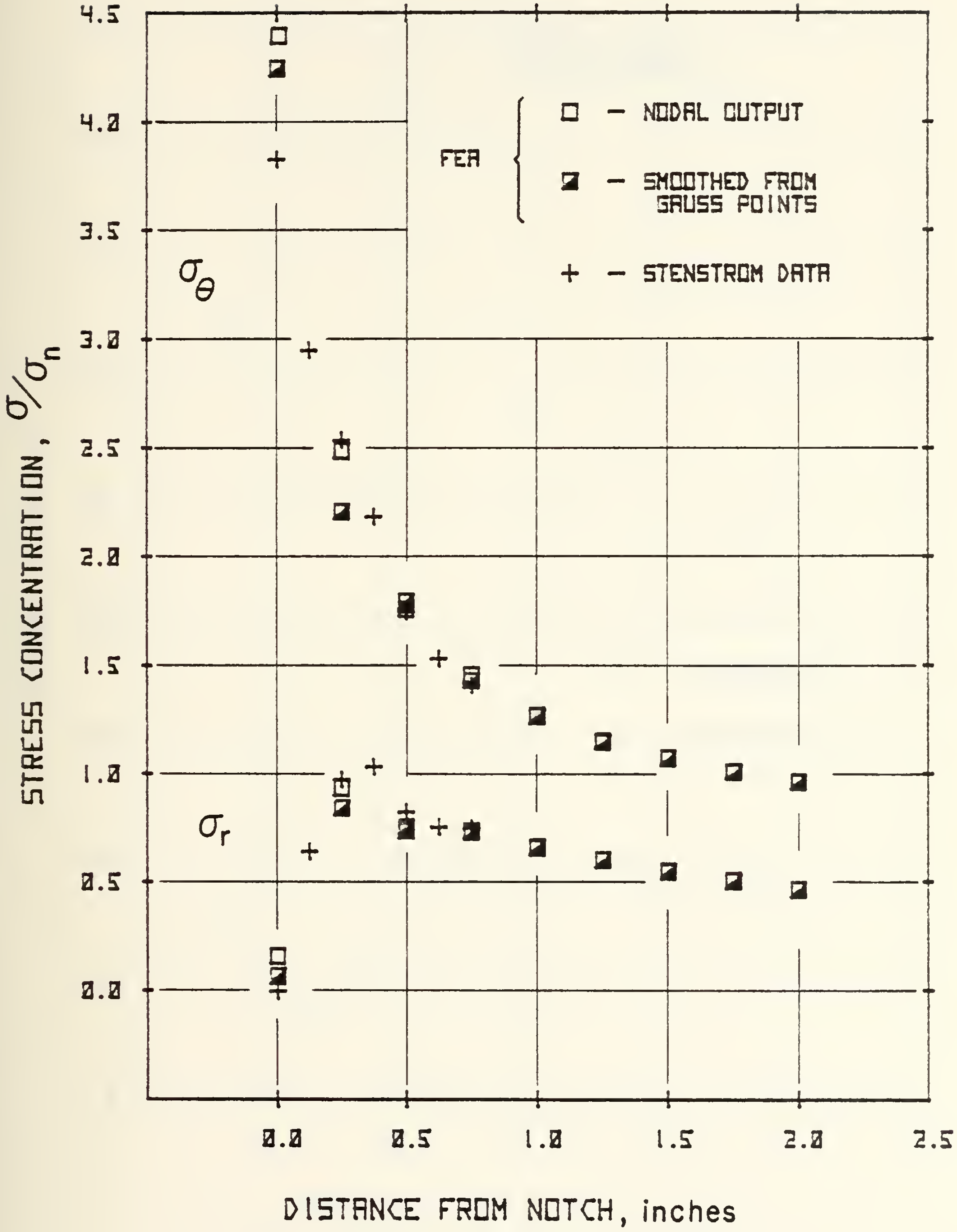


FIGURE 19

SHALLOW NOTCH 60000LB LOAD ELASTIC-PLASTIC RESULTS

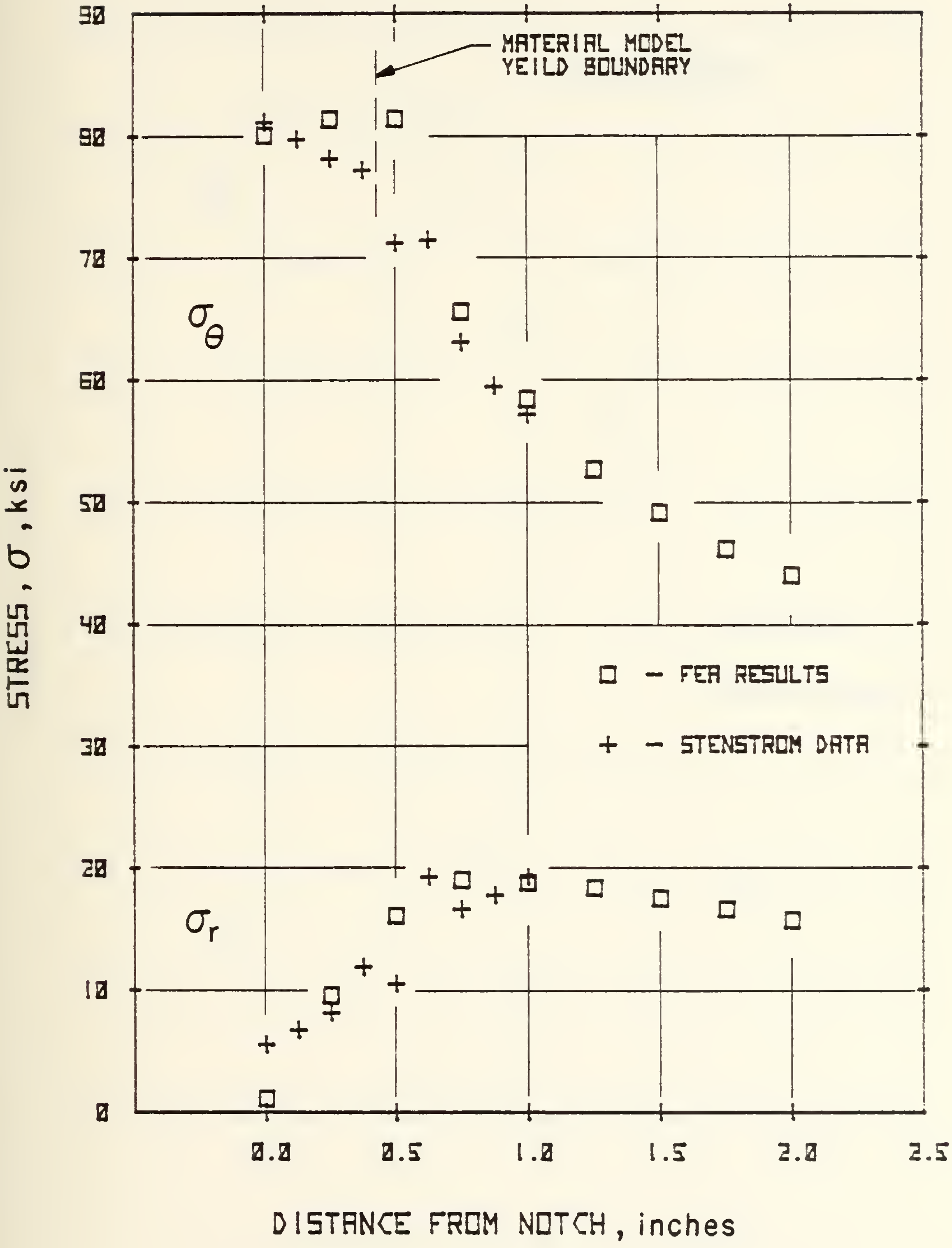


FIGURE 20

SHALLOW NOTCH 55000 LB LOAD ELASTIC-PLASTIC RESULTS

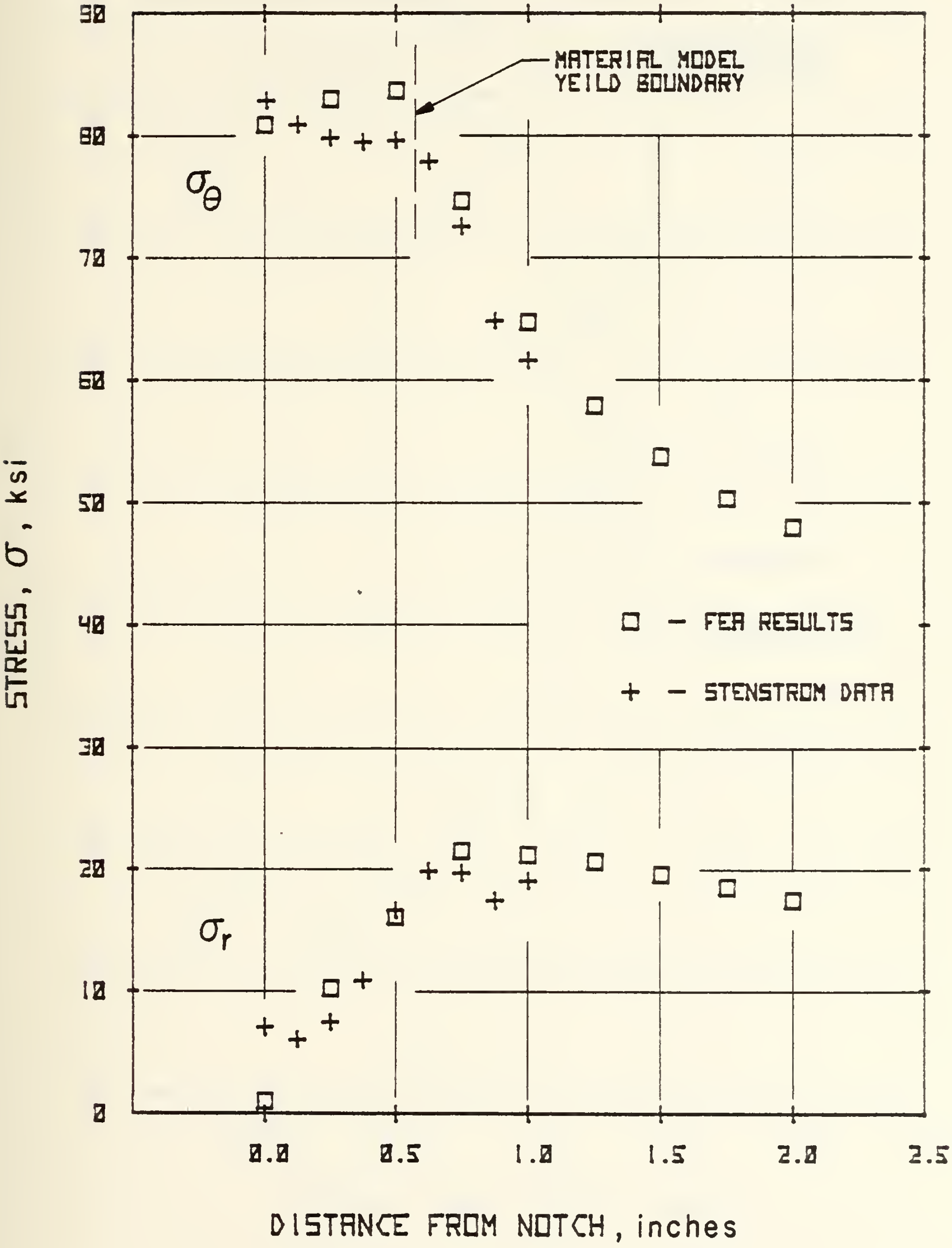
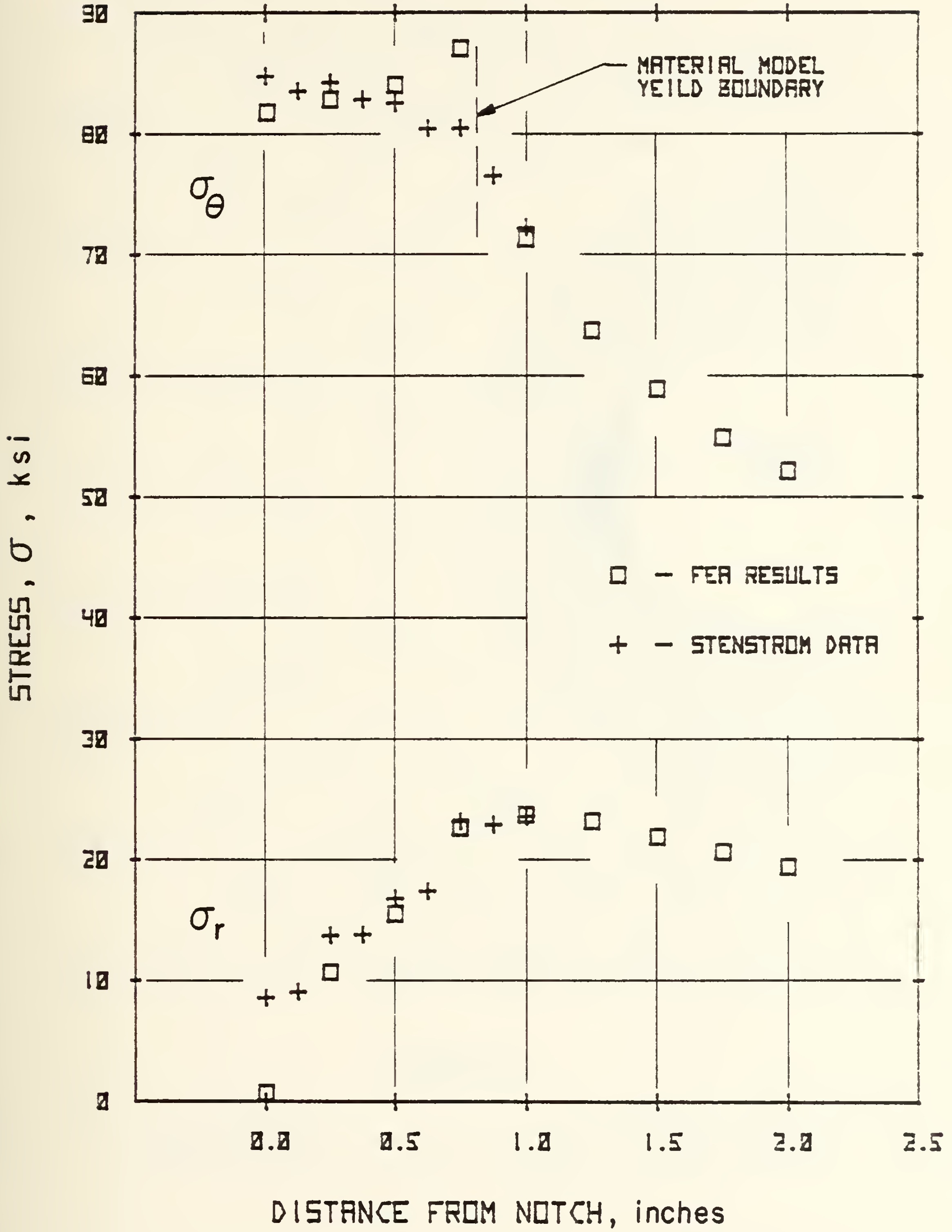


FIGURE 21

SHALLOW NOTCH 70000 LB LOAD ELASTIC-PLASTIC RESULTS



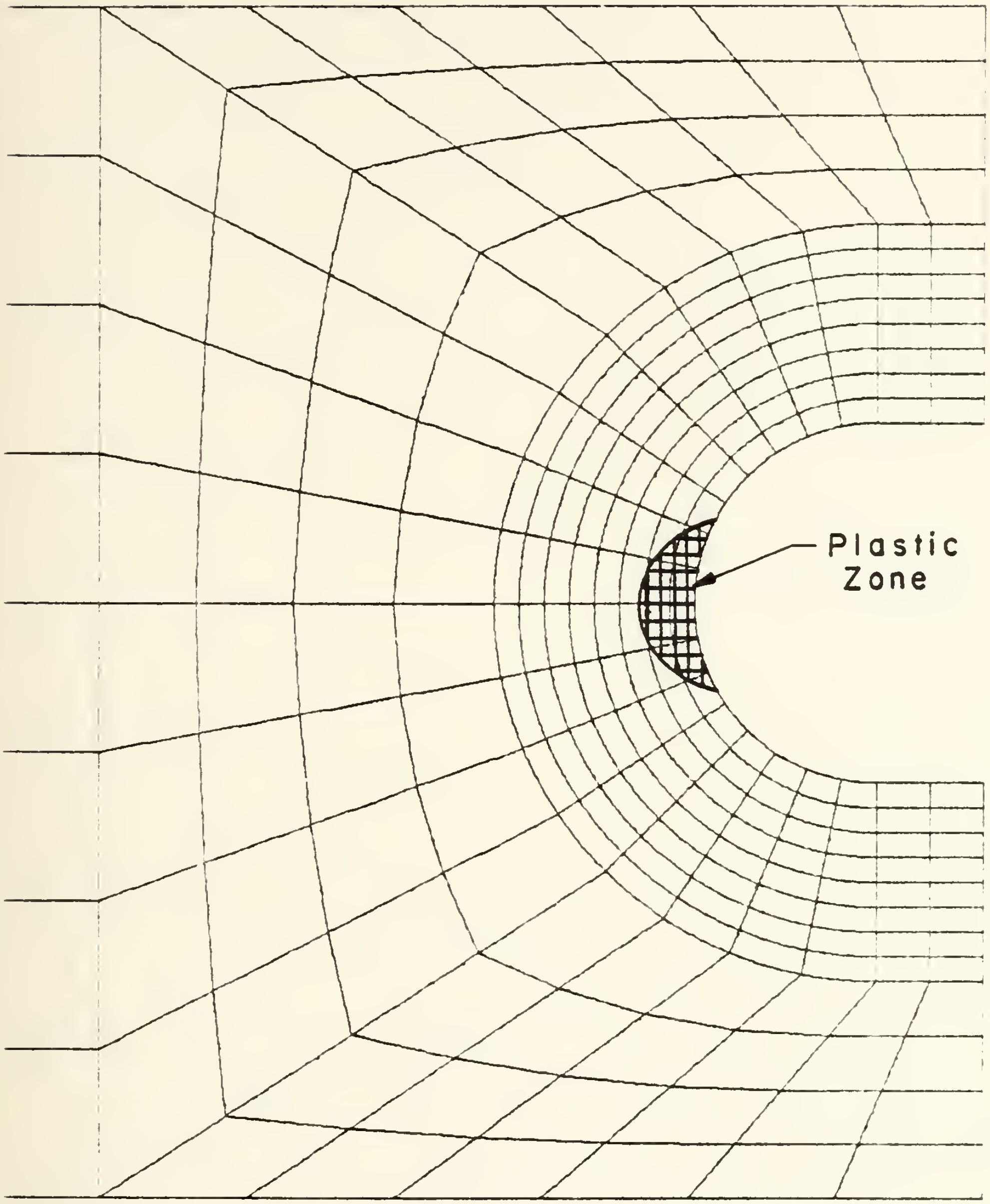


FIGURE 22

SHALLOW NOTCH 60,000 LB LOAD PLASTIC ZONE

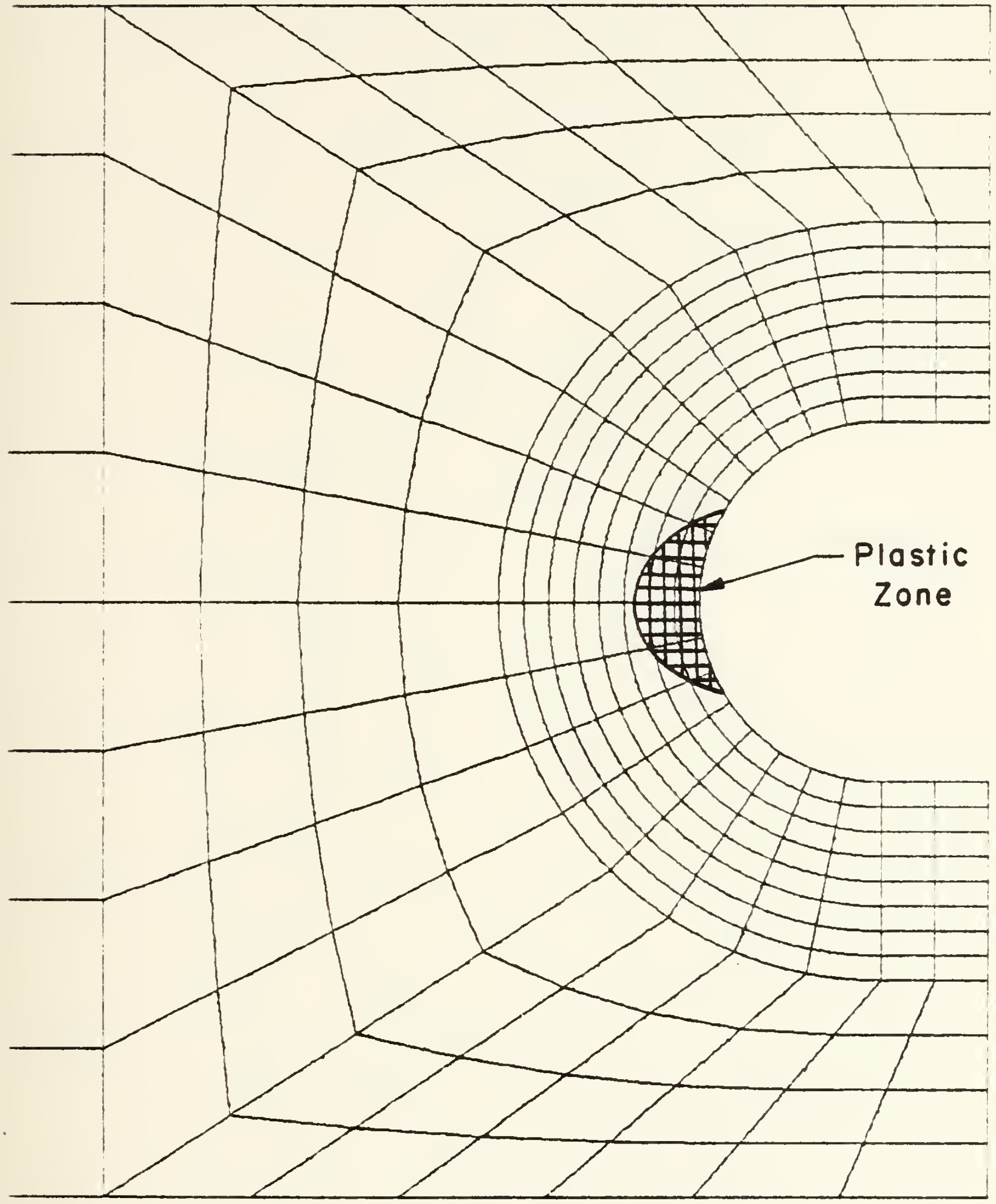


FIGURE 23

SHALLOW NOTCH 65,000 LB LOAD PLASTIC ZONE

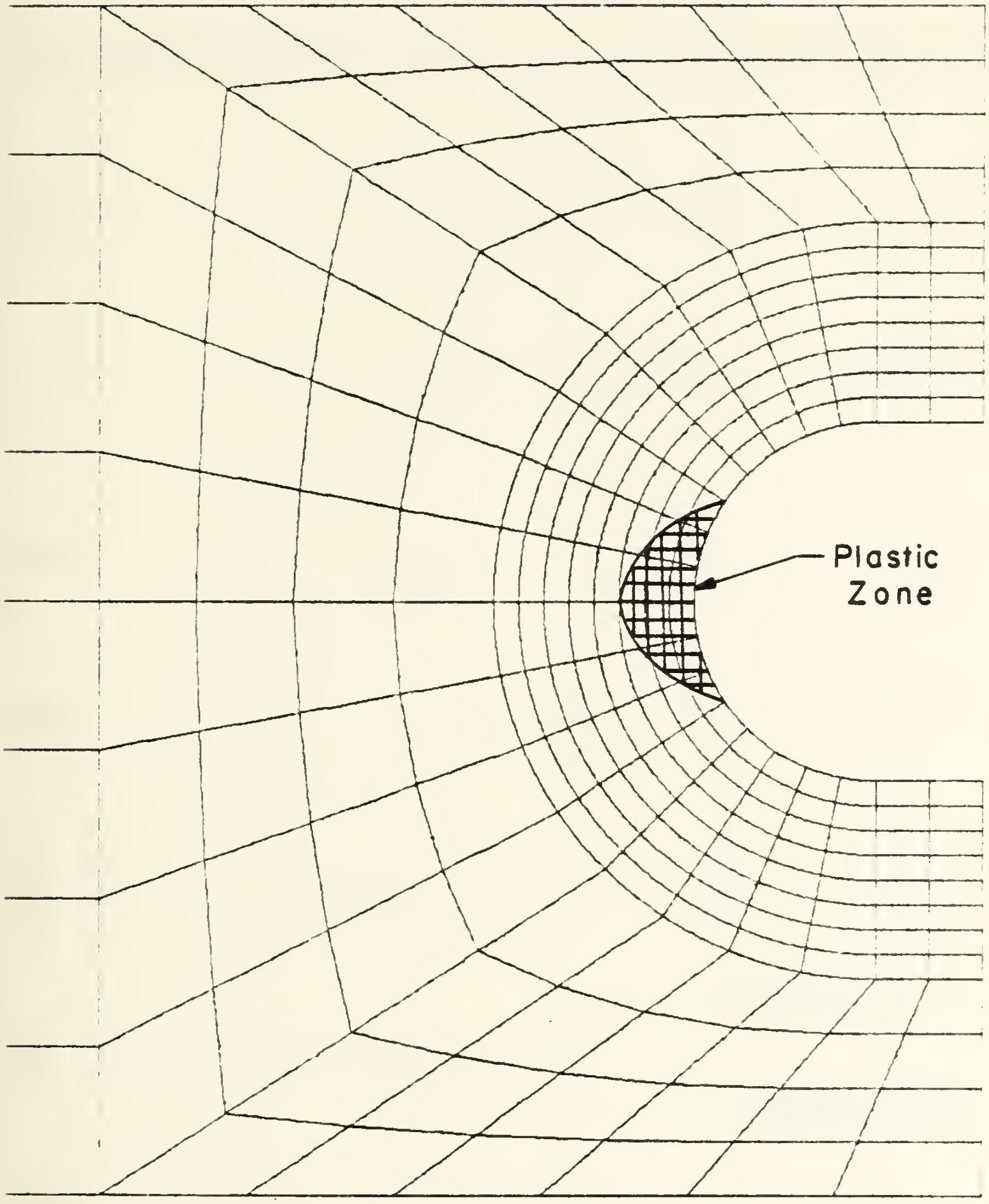


FIGURE 24

SHALLOW NOTCH 70,000 LB LOAD PLASTIC ZONE

FIGURE 25

SHALLOW NOTCH RESIDUAL σ_θ FROM 60,000 LB LOAD

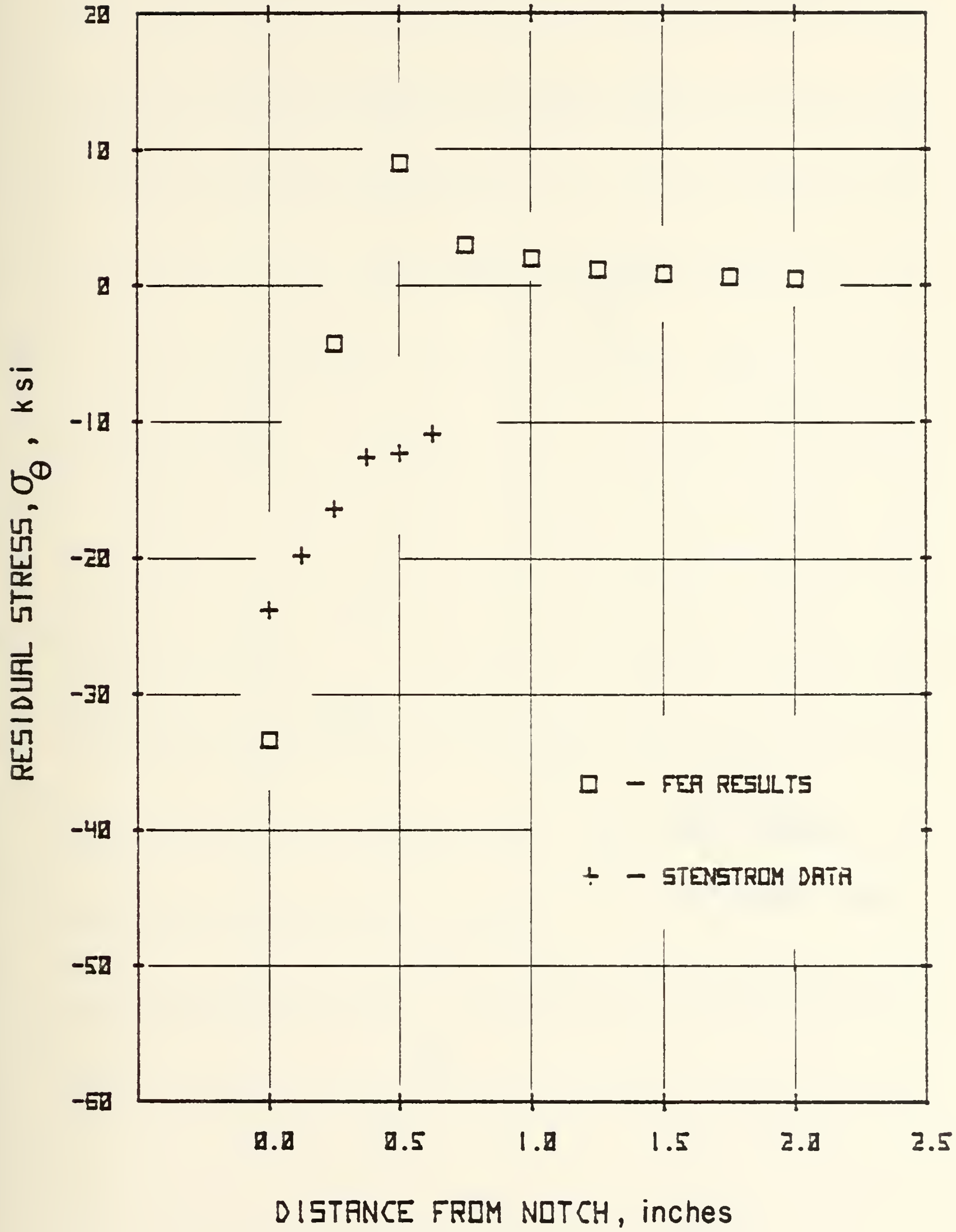


FIGURE 26

SHALLOW NOTCH RESIDUAL σ_r FROM 60,000 LB LOAD

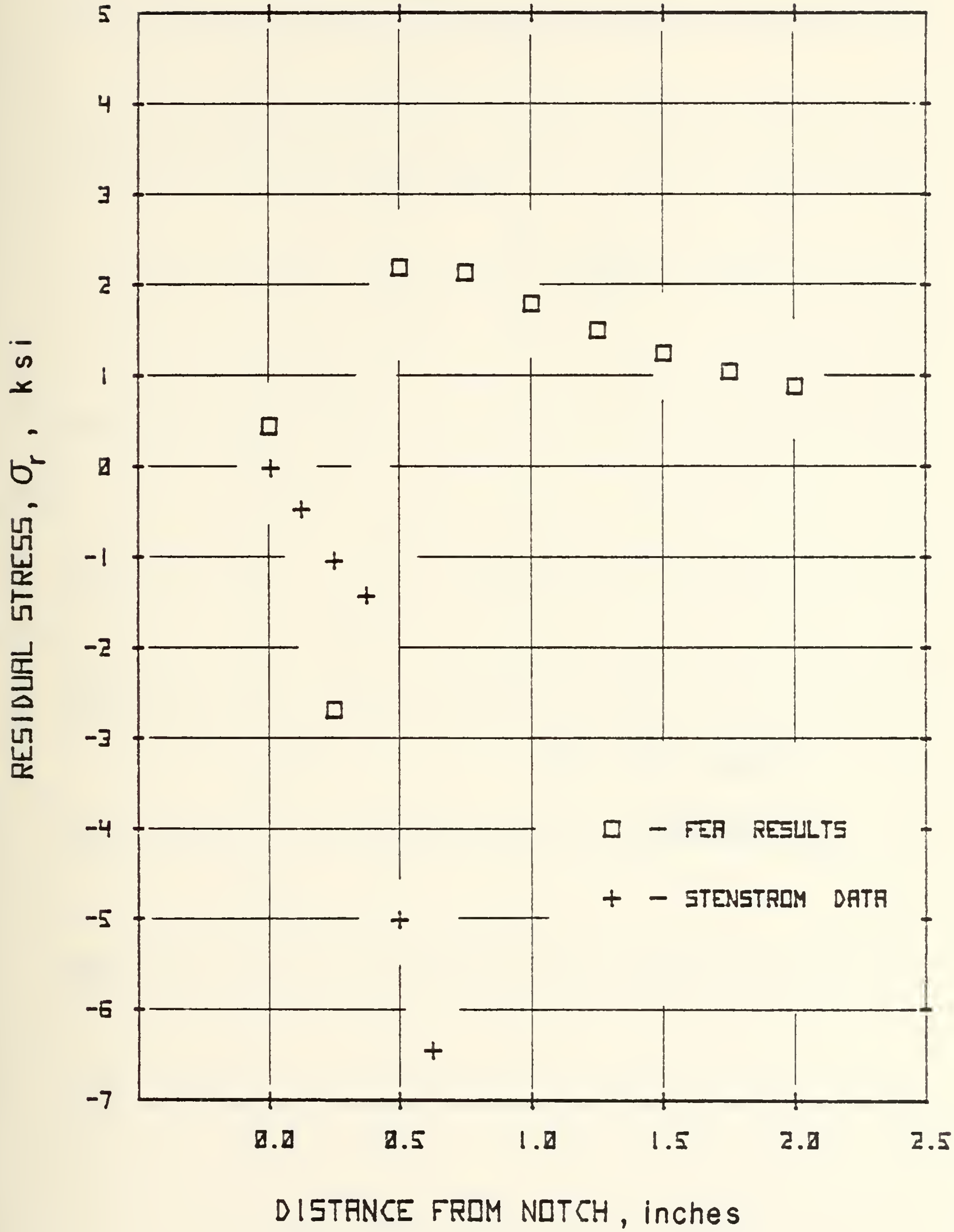


FIGURE 27

SHALLOW NOTCH RESIDUAL σ_θ FROM 65,000 LB LOAD

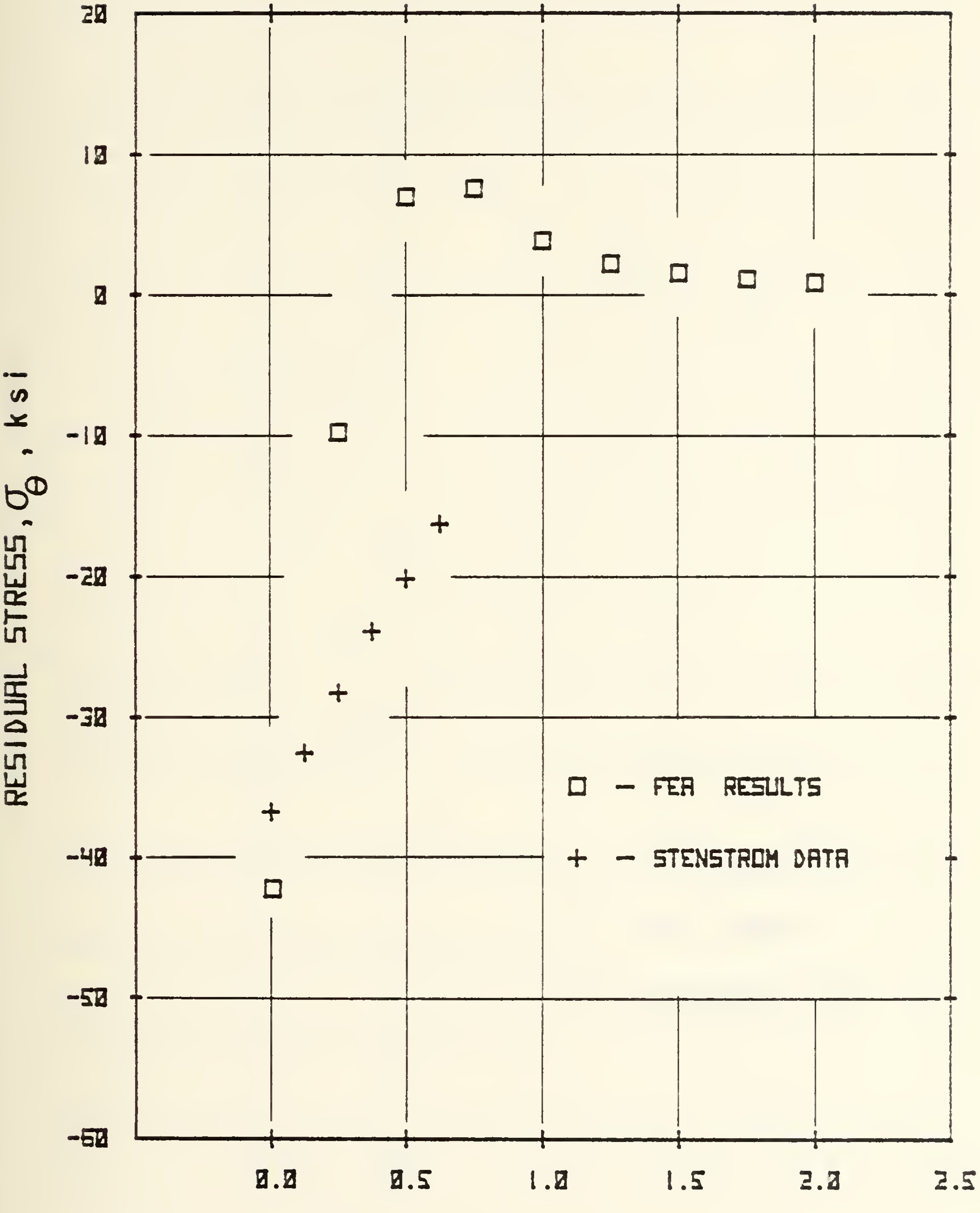


FIGURE 28

SHALLOW NOTCH RESIDUAL σ_r FROM 55,000 LB LOAD

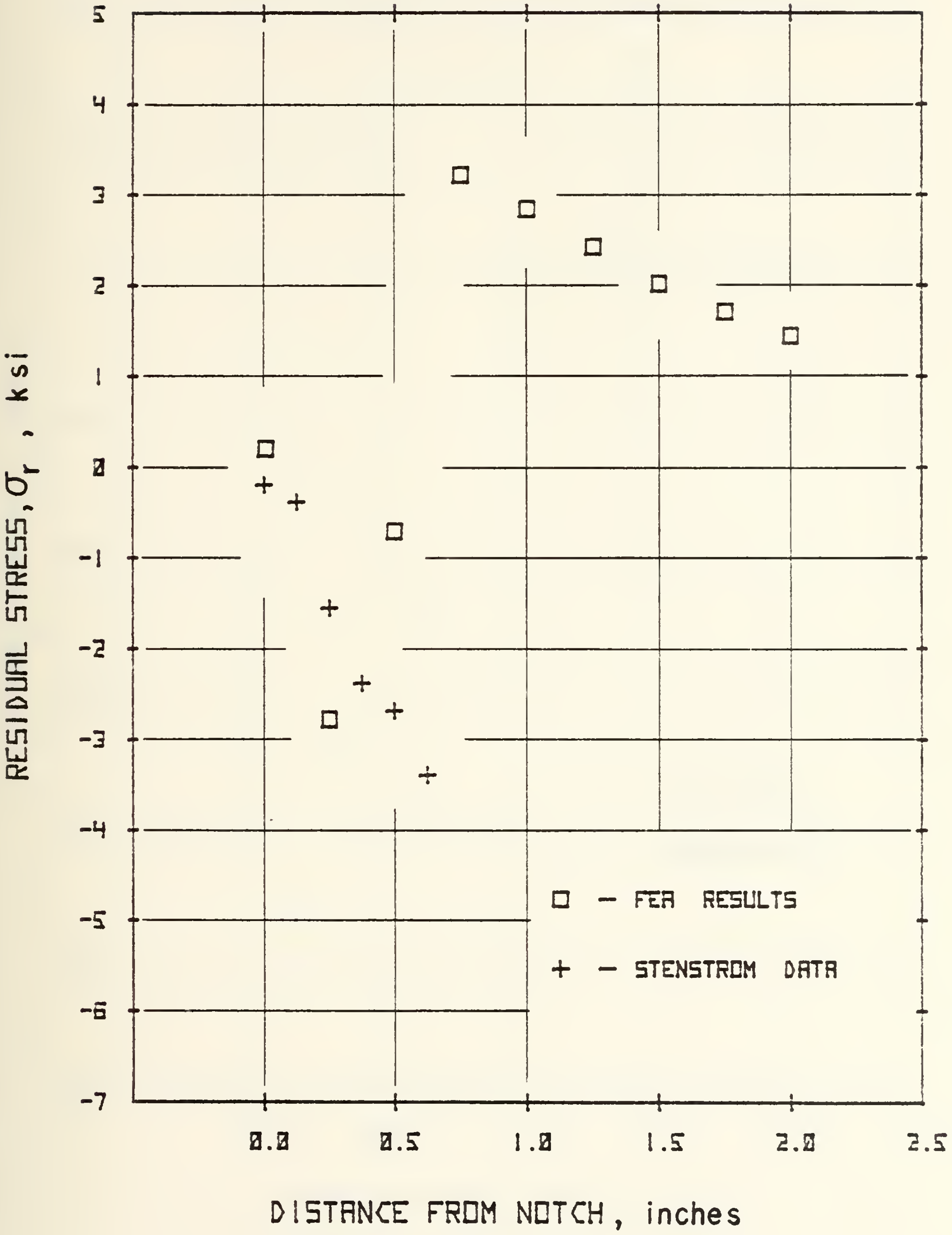


FIGURE 29

SHALLOW NOTCH RESIDUAL σ_Θ FROM 70,000 LB LOAD

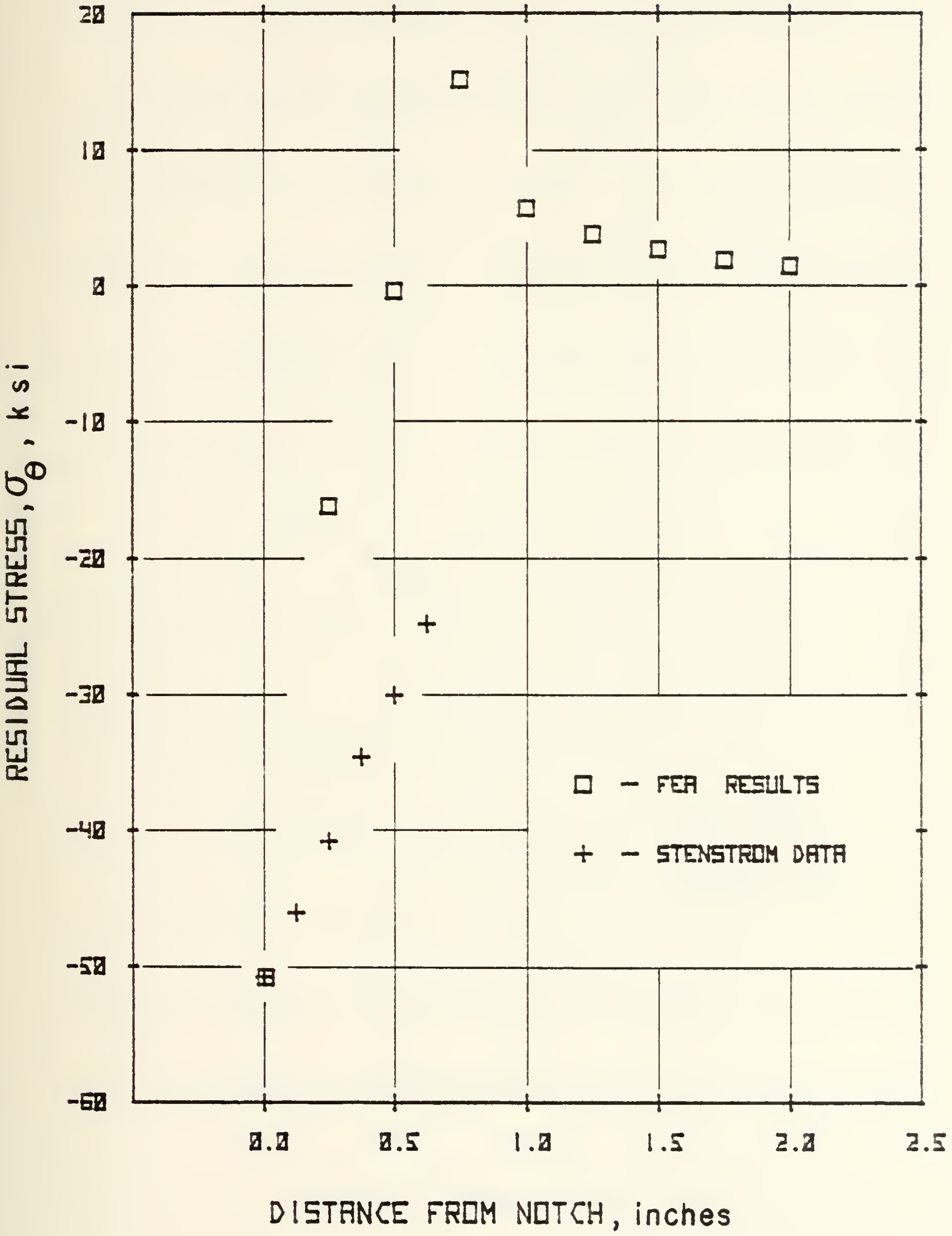


FIGURE 30

SHALLOW NOTCH RESIDUAL σ_r FROM 70,000 LB LOAD

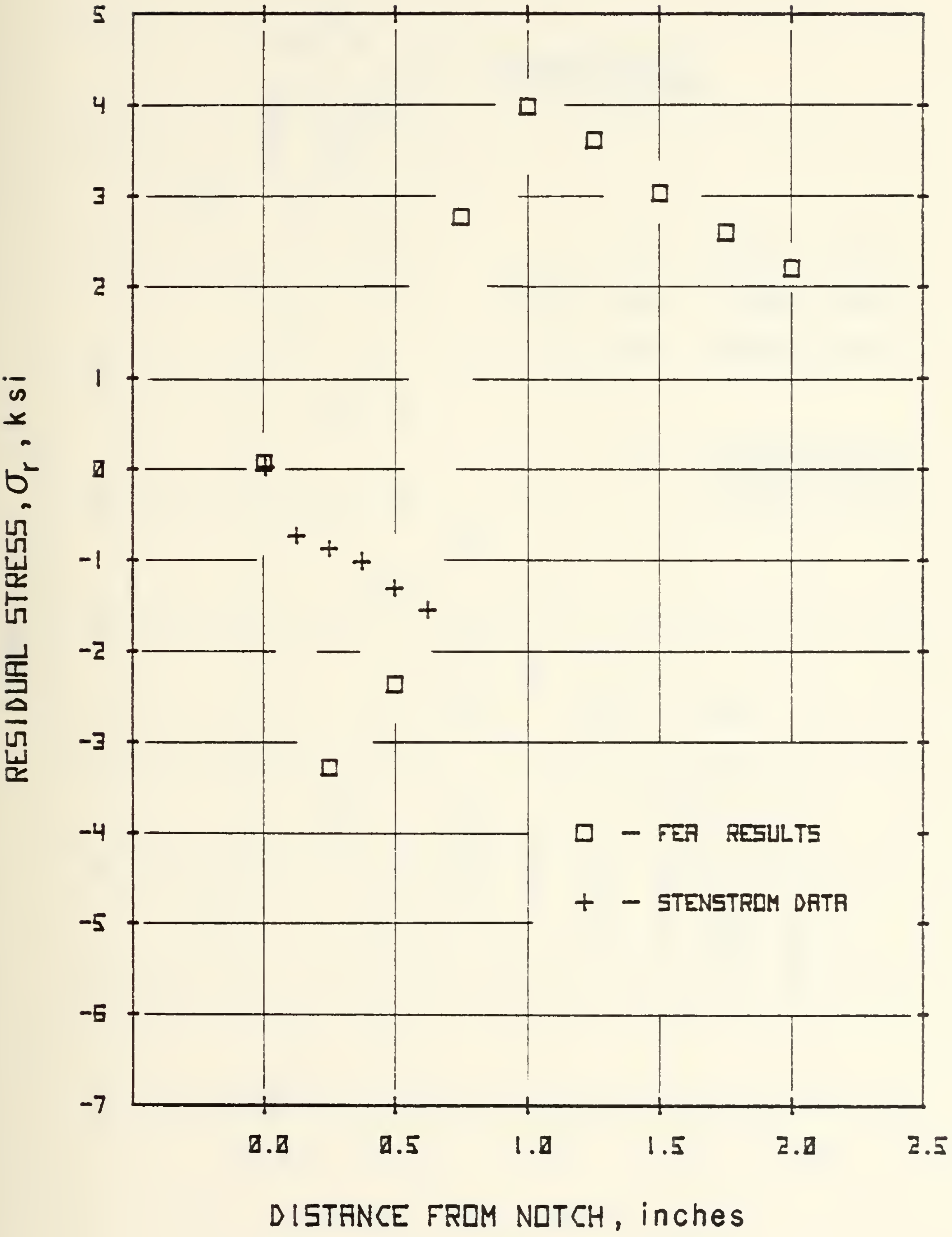


FIGURE 31

DEEP NOTCH PLASTIC LOADING RESULTS

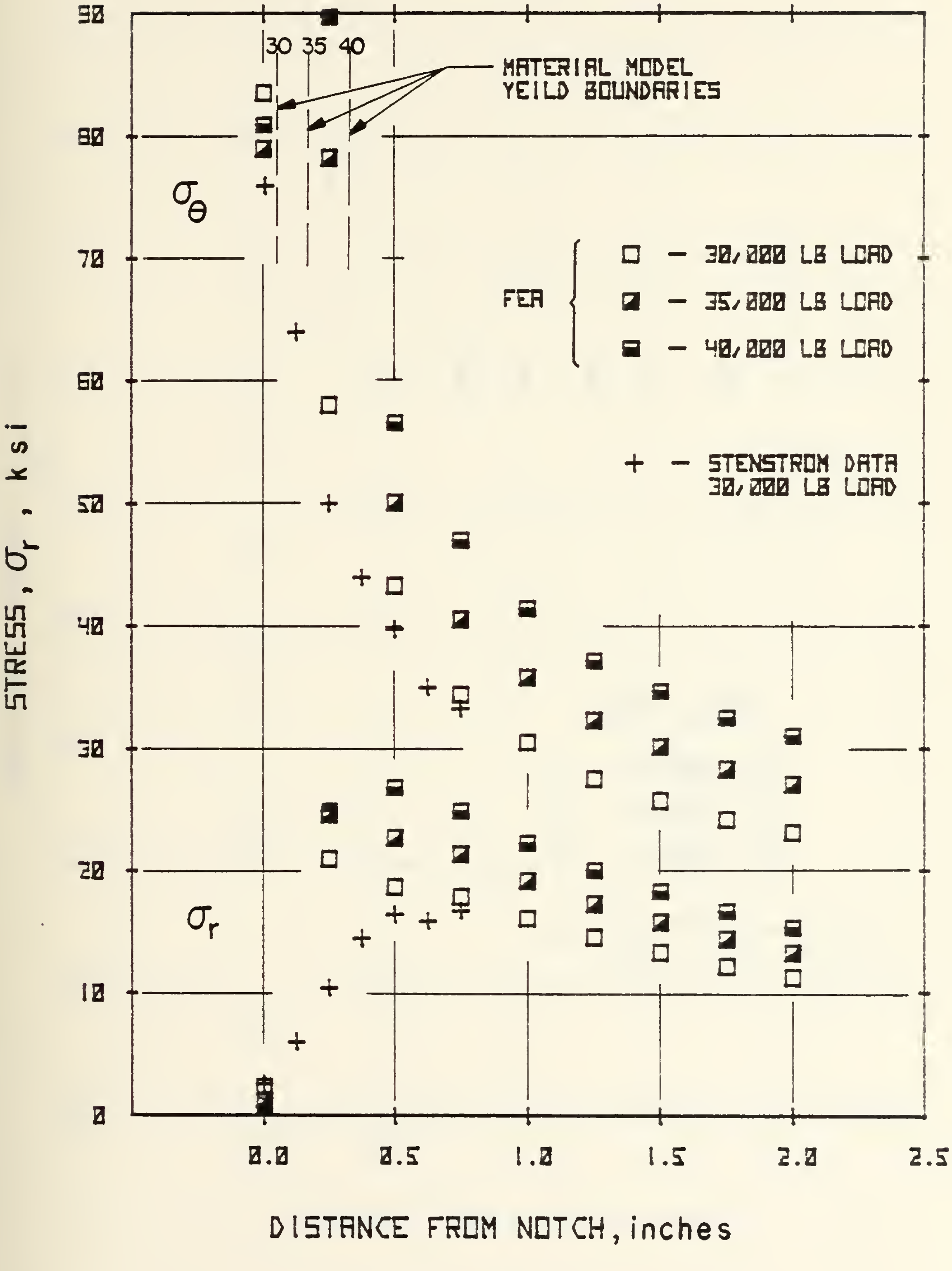


FIGURE 32

DEEP NOTCH σ_θ RESIDUALS

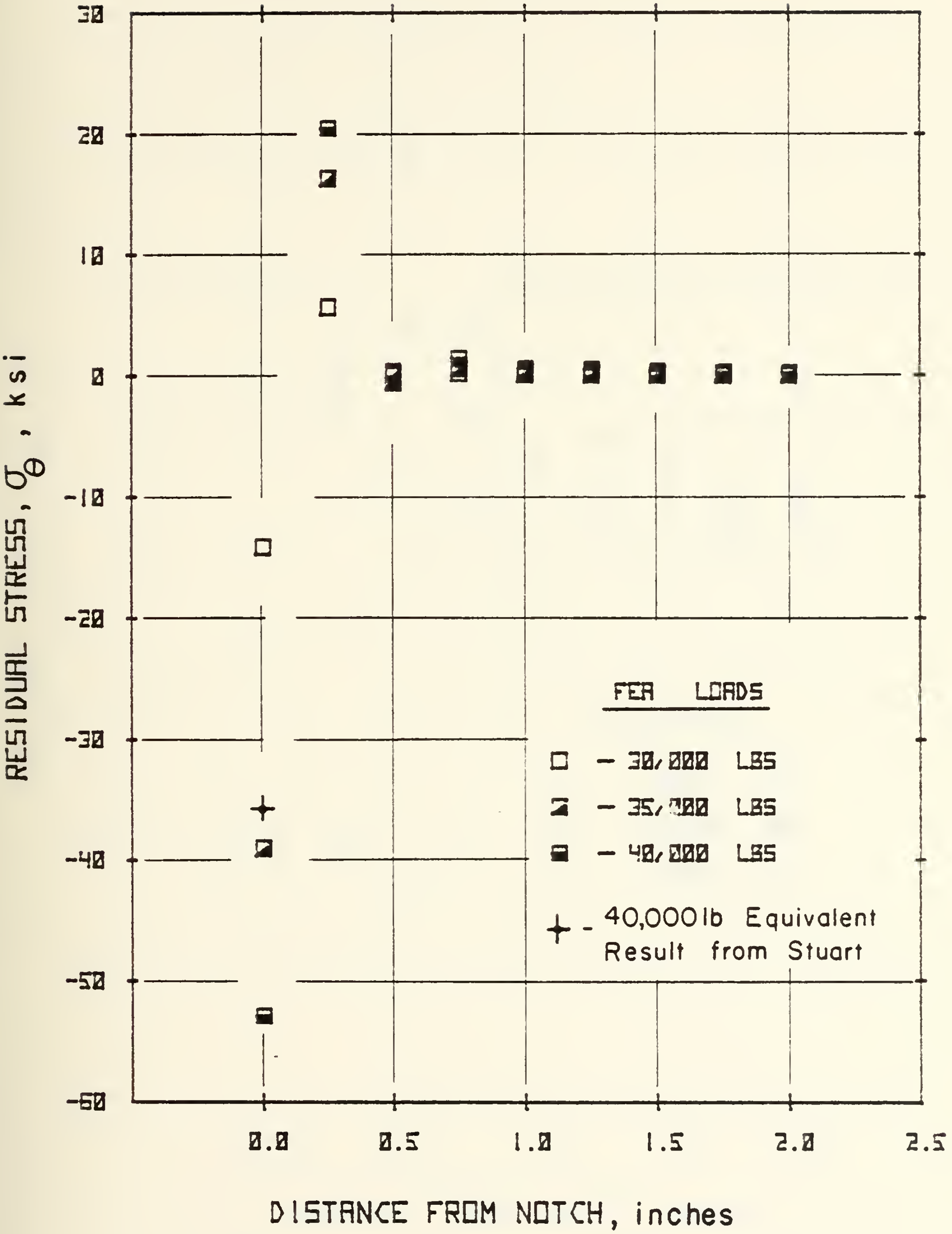
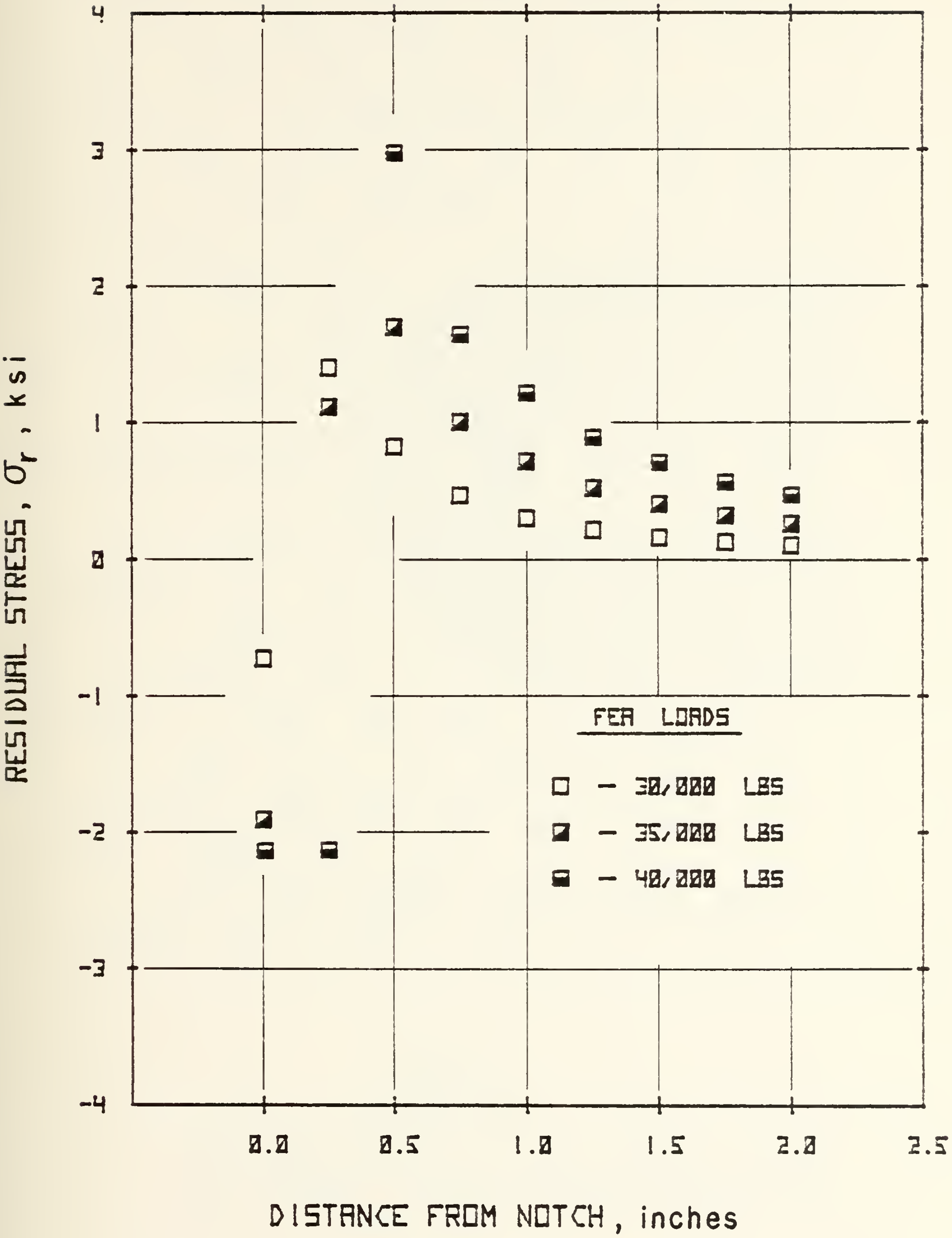


FIGURE 33

DEEP NOTCH σ_r RESIDUALS



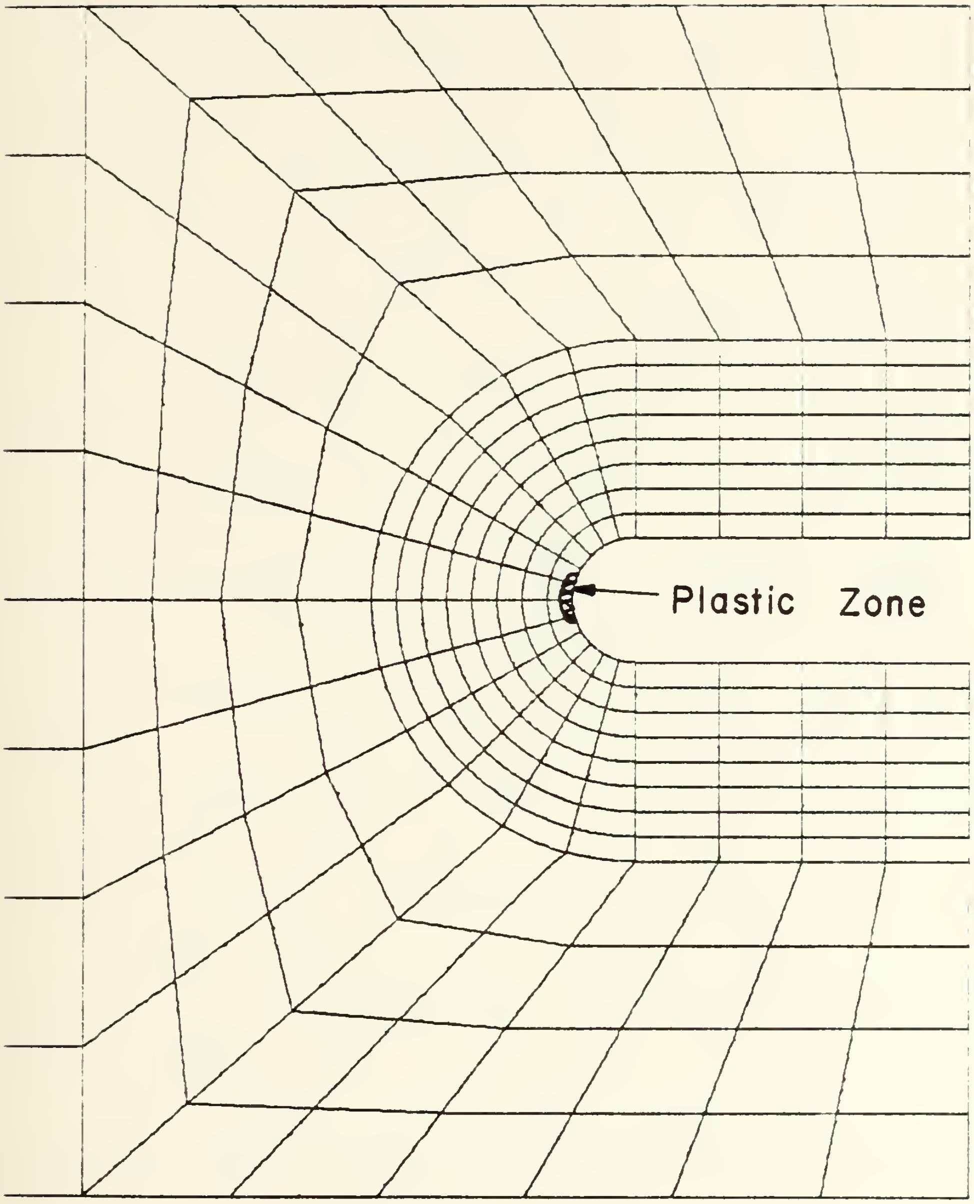


FIGURE 34

DEEP NOTCH 30,000 LB LOAD PLASTIC ZONE

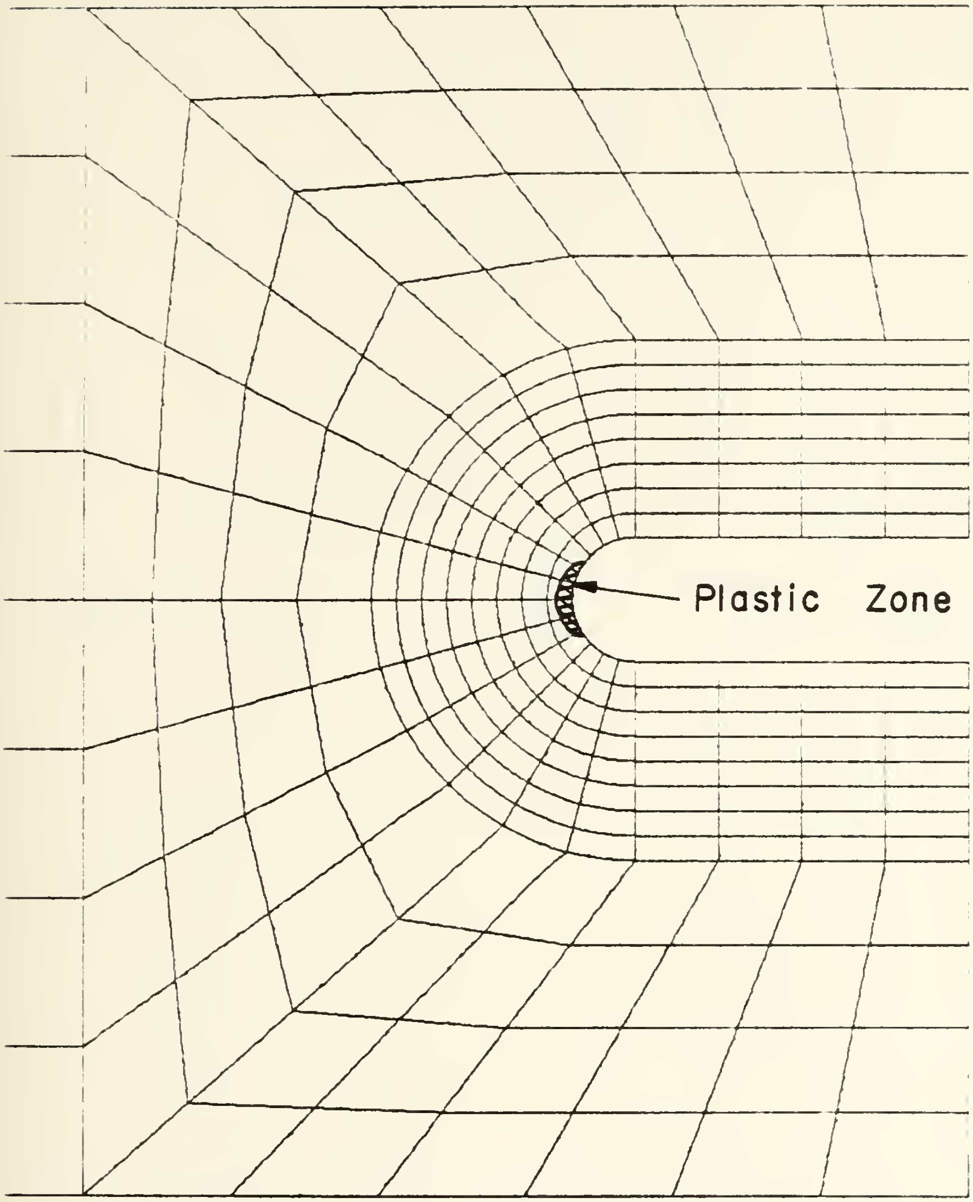


FIGURE 35

DEEP NOTCH 35,000 LB LOAD PLASTIC ZONE

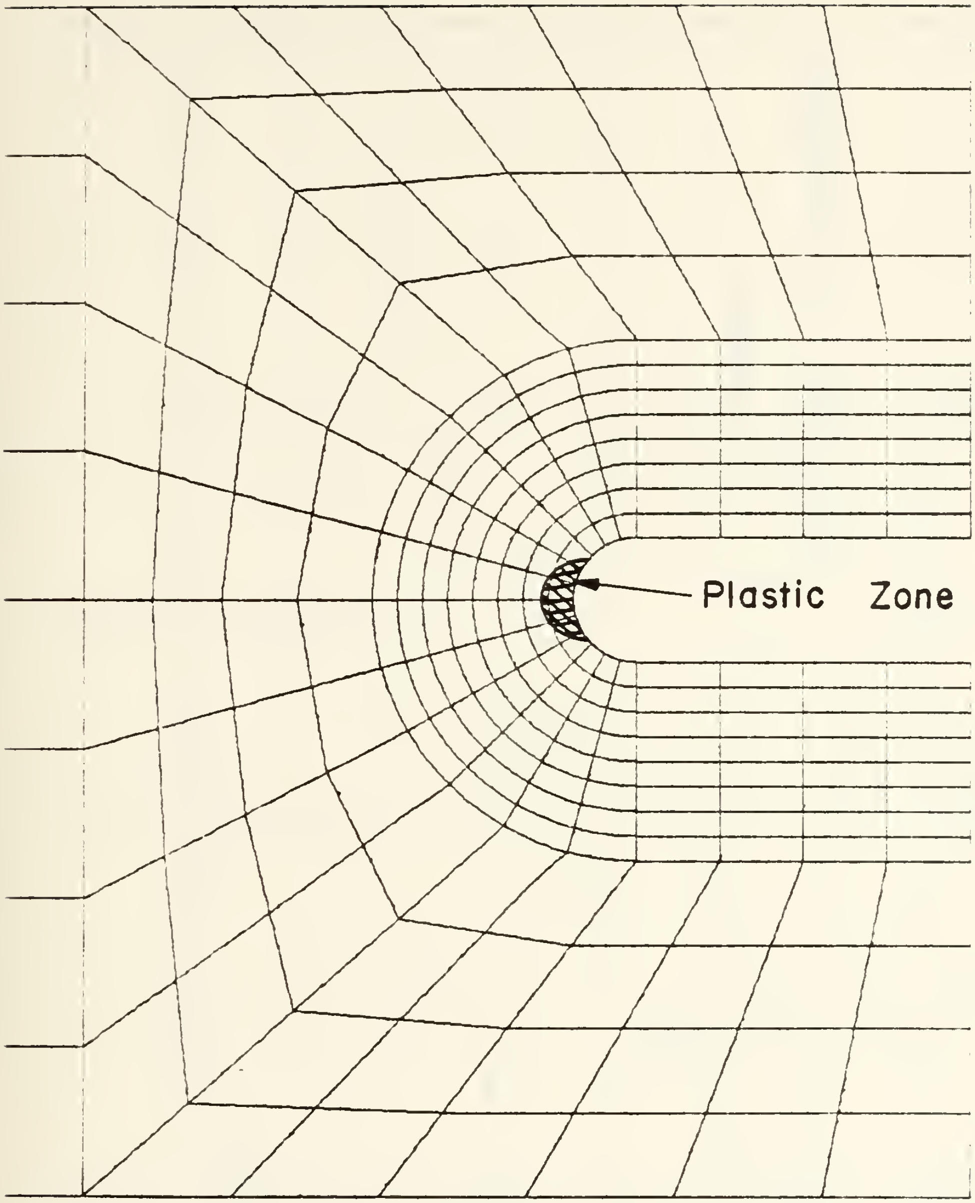
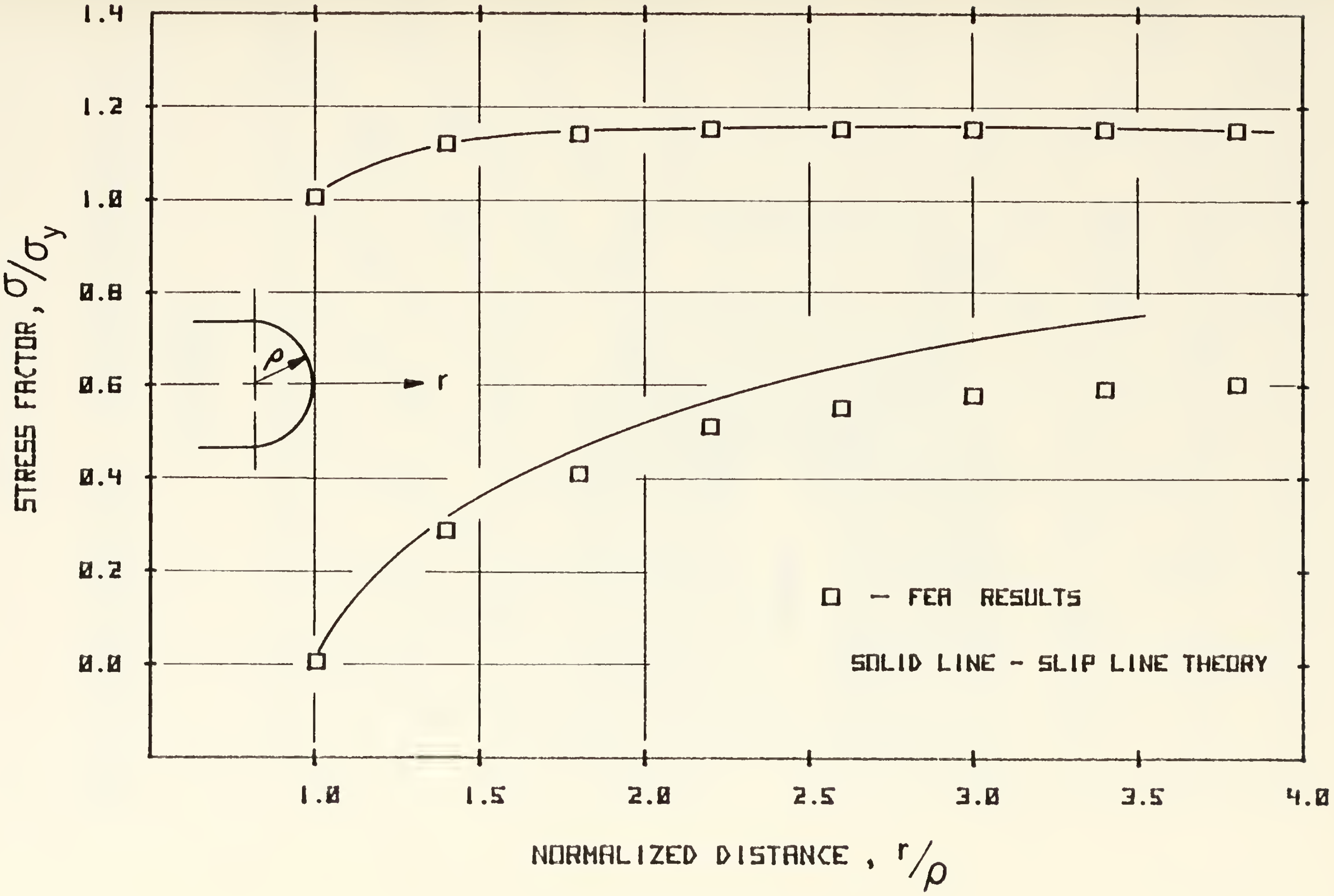


FIGURE 36

DEEP NOTCH 40,000 LB LOAD PLASTIC ZONE

FIGURE 37

RIGID-PERFECTLY-PLASTIC RESULTS



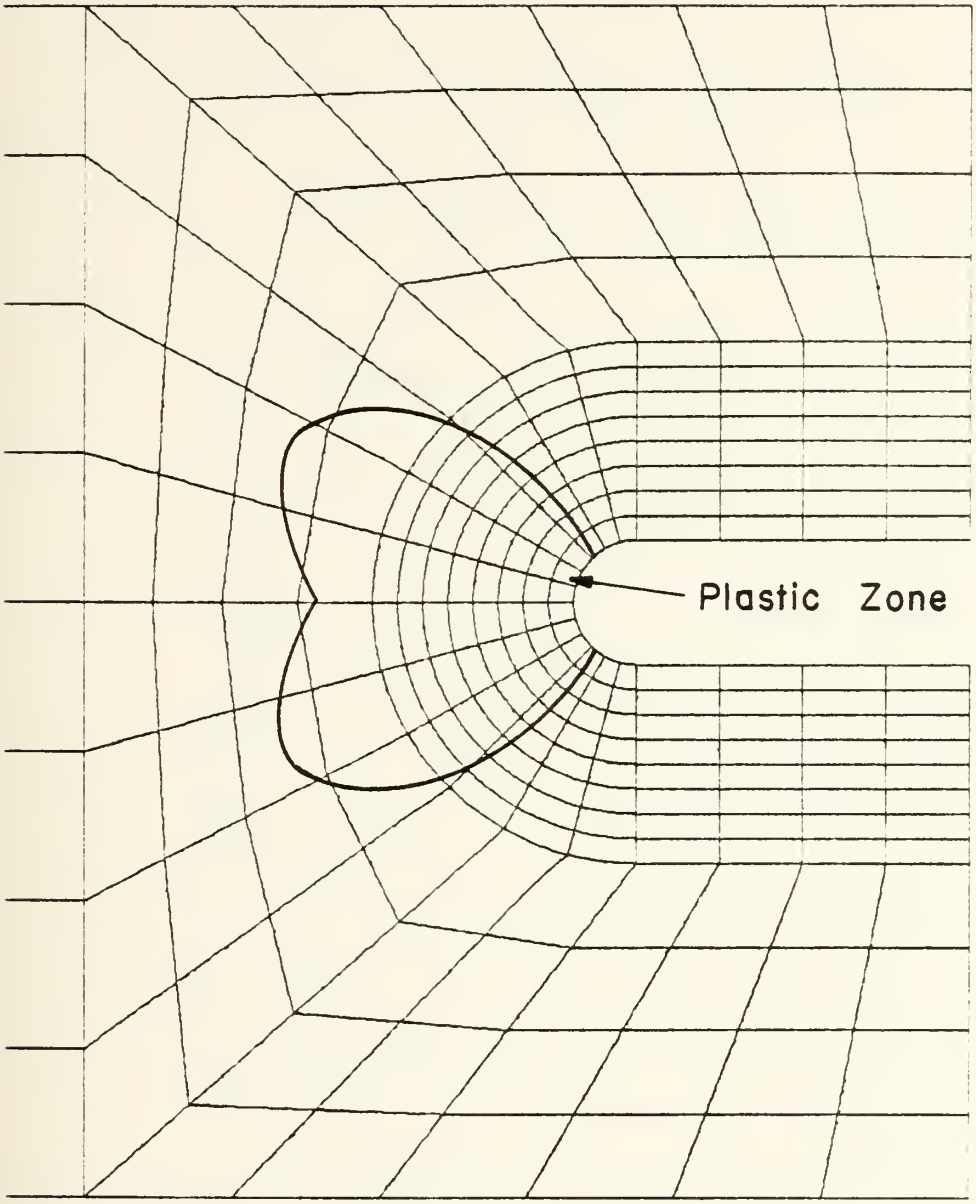


FIGURE 38

RIGID-PERFECTLY-PLASTIC INITIAL PLASTIC ZONE

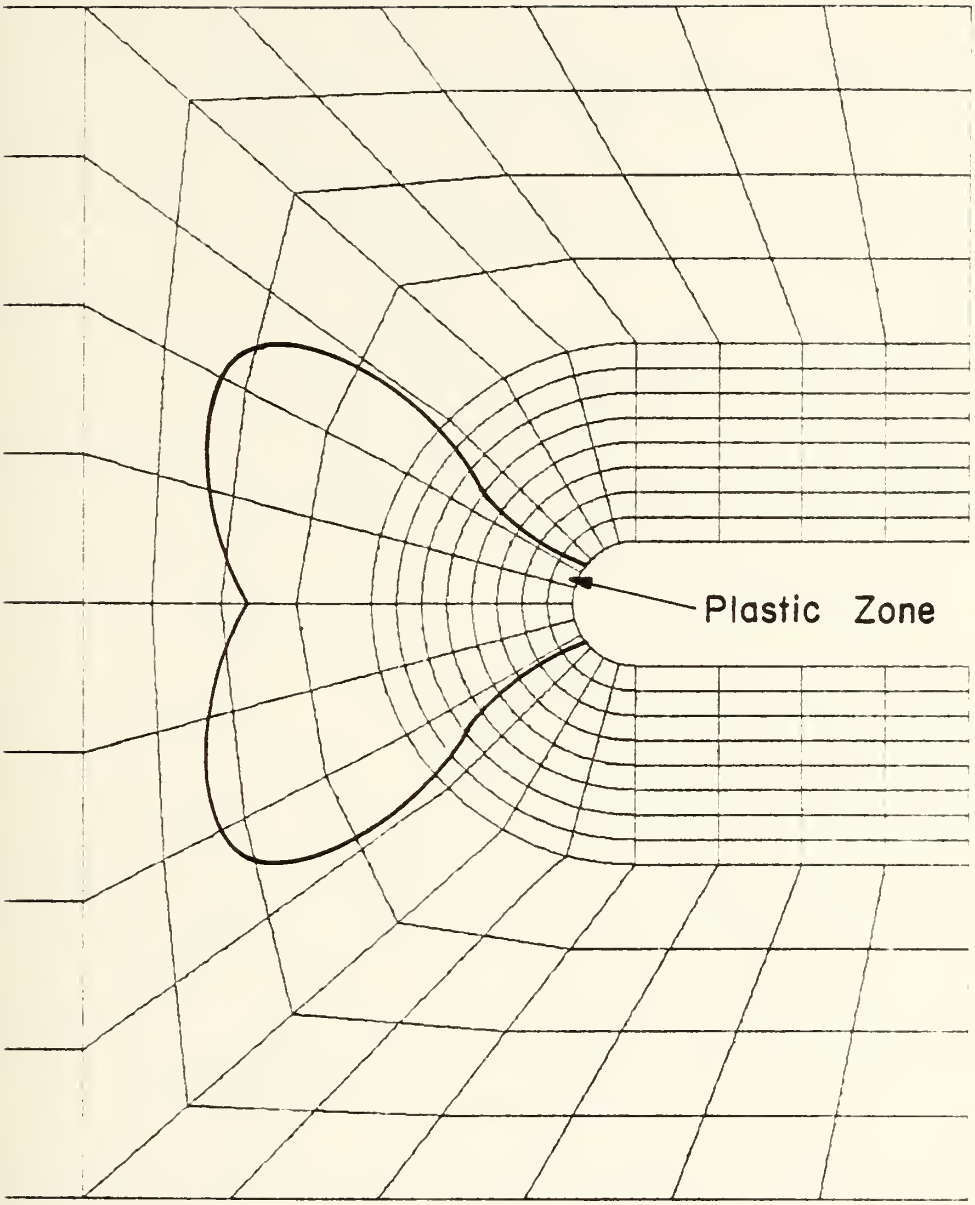


FIGURE 39

RIGID-PERFECTLY-PLASTIC INTERMEDIATE PLASTIC ZONE

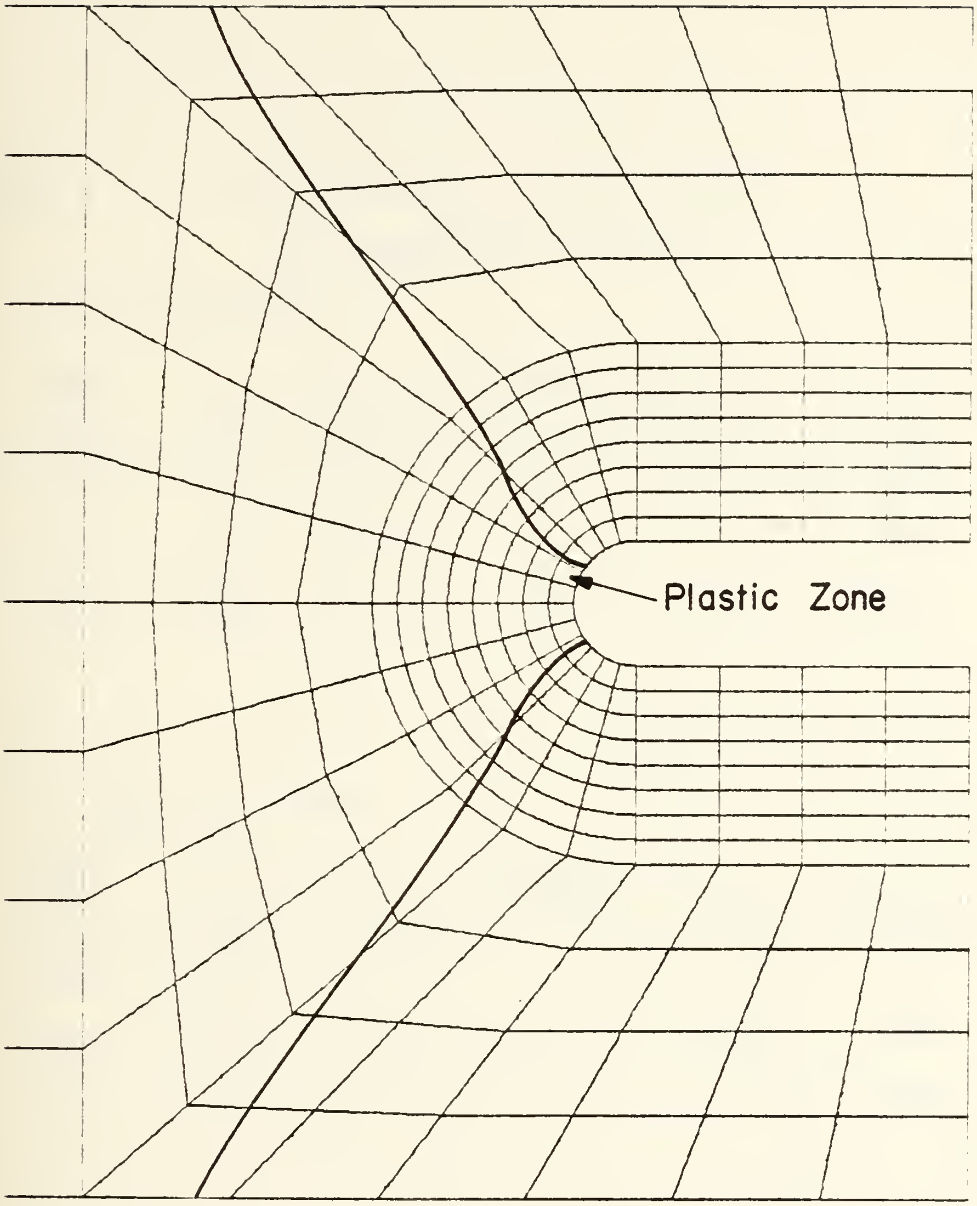


FIGURE 40

RIGID-PERFECTLY-PLASTIC FINAL PLASTIC ZONE

TABLE I. MTS AND REIHLE 5 GAGE TEST RESULTS

All Strains are 10^{-6} in/in

MTS Test Machine

LOAD lbs	STRAINS				
	ε_1	ε_2	ε_3	ε_4	ε_5
1000	-3	421	814	1235	1638
2000	338	1003	1619	2279	2903
3000	960	1714	2431	3186	3908

REIHLE Test Machine

LOAD lbs	STRAINS				
	ε_1	ε_2	ε_3	ε_4	ε_5
1000	800	763	755	741	726
2000	1564	1540	1546	1543	1535
3000	2370	2334	2363	2377	2388

TABLE II. MTS SPECIMEN A TEST RESULTS

Cross-section = 0.03975 in^2

Load, lbs.	Strain, $\varepsilon, 10^{-6}$ in/in
256	615
503	1204
750	1801
1005	2423
1255	3042
1505	3665
1778	4352
2003	4925
2252	5587
2508	6355
2755	7365
2905	8230
2984	9045
3037	10150

TABLE III. MTS SPECIMEN B TEST RESULTS

Cross-section = 0.03975 in^2

Load, lbs.	Strain, ε, 10^{-6} in/in
500	1250
750	1860
1000	2450
1250	3080
1500	3700
1750	4320
2000	4950
2250	5630
2500	6380
2750	7340
2900	8200
3000	9250
3050	10200
3100	11550
3125	12800

TABLE IV. MTS SPECIMEN C TEST RESULTS

Cross-section = 0.03975 in^2

Load, lbs.	Strain, ε, 10^{-6} in/in
272	663
503	1220
762	1856
1008	2451
1231	3065
1506	3690
1755	4313
2000	4940
2255	5607
2503	6325
2750	7230
2900	8120
3000	9200
3060	10500
3100	11500
3125	12500

TABLE V. REIHLE SPECIMEN TEST RESULTS

Cross-section = 0.12 in^2

LOAD lbs.	STRAIN, ε_1 10^{-6} in/in	STRAIN, ε_2 10^{-6} in/in
500	345	-115
1000	720	-240
1500	1114	-364
2000	1501	-492
2500	1895	-614
3000	2291	-745
3500	2705	-871
4000	3095	-999
4500	3515	-1126
5000	3912	-1255
5500	4332	-1394
6000	4750	-1520
6500	5188	-1647
7000	5595	-1784
7500	6075	-1928
8000	6649	-2108
8500	7285	-2375
9000	8663	-2888
9500	12245	-4435

TABLE VI. $\lambda = 0.2$ HOWLAND DATA

DISTANCE FROM HOLE in.	$\sigma_\theta/\sigma_\infty$
0.0	3.14
0.5	1.57
1.0	1.26
1.5	1.16
2.0	1.11
2.5	1.07
3.0	1.05
3.5	1.01
4.0	0.97

TABLE VII. $\lambda = 0.25$ HOWLAND DATA

DISTANCE FROM HOLE in.	$\sigma_\theta/\sigma_\infty$
0.000	3.23
0.422	1.75
0.828	1.30
1.234	1.22
1.641	1.13
2.047	1.07
2.453	1.04
2.859	0.97
3.063	0.95

TABLE VIII. $\lambda = 0.2$ FEA RESULTS - NODAL OUTPUT

$\sigma_\infty = 5000$ psi

DISTANCE FROM HOLE, in.	σ_θ, psi	σ_r , psi
0.00	15938.2	351.7
0.25	10259.7	2375.8
0.50	7875.7	1783.5
0.75	6877.0	1673.1
1.00	6307.4	1334.7
1.25	5995.4	1087.2
1.50	5797.7	874.4
1.75	5633.9	700.5
2.00	5509.8	556.8

TABLE IX. $\lambda = 0.2$ FEA RESULTS - GAUSS OUTPUT

$\sigma_\infty = 5000$ psi

DISTANCE FROM HOLE, in.	σ_θ ,psi	σ_r ,psi
0.00	15595.4	128.9
0.25	9482.6	2104.1
0.50	7953.8	1826.6
0.75	6783.7	1650.4
1.00	6316.1	1348.7
1.25	5975.6	1088.8
1.50	5795.8	880.1
1.75	5623.8	695.7
2.00	5499.9	554.9

TABLE X. $\lambda = 0.25$ FEA RESULTS - NODAL OUTPUT

$\sigma_\infty = 4500$ psi

DISTANCE FROM HOLE, in.	σ_θ ,psi	σ_r ,psi
0.00	14745.5	329.8
0.25	9447.0	2181.1
0.50	7232.6	1599.3
0.75	6304.7	1473.5
1.00	5771.7	1139.6
1.25	5471.2	891.6
1.50	5266.9	671.0
1.75	5091.7	489.1
2.00	4940.2	354.5

TABLE XI. $\lambda = 0.25$ FEA RESULTS - GAUSS OUTPUT

$\sigma_\infty = 4500$ psi

DISTANCE FROM HOLE, in.	σ_θ ,psi	σ_r ,psi
0.00	14422.8	121.2
0.25	8721.2	1927.1
0.50	7317.1	1639.7
0.75	6218.6	1452.4
1.00	5779.6	1151.5
1.25	5453.3	891.0
1.50	5267.1	677.3
1.75	5085.9	486.9
2.00	4937.9	343.8

TABLE XII. SHALLOW NOTCH FEA LINEAR RESULTS - NODAL

$\sigma_n = 4225$ psi

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.00	11584.9	94.5
0.25	8966.1	1279.9
0.50	7335.6	1501.9
0.75	6347.3	1731.7
1.00	5655.0	1713.2
1.25	5184.1	1703.5
1.50	4832.4	1626.7
1.75	4564.7	1560.6
2.00	4361.1	1484.7

TABLE XIII. SHALLOW NOTCH FEA LINEAR RESULTS - GAUSS

$\sigma_n = 4225$ psi

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.00	11530.2	11.5
0.25	8727.1	1177.7
0.50	7355.5	1504.8
0.75	6280.9	1713.6
1.00	5661.2	1720.4
1.25	5159.3	1699.7
1.50	4834.6	1634.2
1.75	4552.8	1561.7
2.00	4353.6	1486.0

TABLE XIV. DEEP NOTCH FEA LINEAR RESULTS - NODAL

$\sigma_n = 4800$ psi

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.00	21142.8	755.2
0.25	11929.9	4484.3
0.50	8436.8	3530.4
0.75	6976.6	3524.4
1.00	6076.1	3152.2
1.25	5527.0	2883.4
1.50	5139.2	2623.4
1.75	4842.4	2412.0
2.00	4617.8	2234.2

TABLE XV. DEEP NOTCH FEA LINEAR RESULTS - GAUSS

$\sigma_n = 4800$ psi

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.00	20368.1	314.0
0.25	10582.5	4035.2
0.50	8606.0	3611.8
0.75	6852.2	3501.9
1.00	6086.7	3172.2
1.25	5496.1	2884.7
1.50	5141.3	2640.0
1.75	4830.1	2421.2
2.00	4622.0	2238.8

TABLE XVI. SHALLOW NOTCH FEA NONLINEAR 60,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS σ_θ ,psi	NO LOAD RESIDUALS σ_r ,psi
0.00	80024.7	1094.5	-33411.4	439.1
0.25	81338.7	9523.3	-4250.0	-2690.1
0.50	81383.6	16052.6	9006.8	2188.8
0.75	65548.3	18993.2	2946.6	2133.4
1.00	58431.4	18799.6	1992.8	1796.7
1.25	52670.1	18347.9	1167.3	1501.6
1.50	49111.1	17477.1	825.7	1250.8
1.75	46080.7	16567.3	594.4	1046.7
2.00	43973.8	15667.8	471.6	885.0

TABLE XVII. SHALLOW NOTCH FEA NONLINEAR 65,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS σ_θ ,psi	NO LOAD RESIDUALS σ_r ,psi
0.00	80890.4	1004.6	-42092.3	224.7
0.25	82939.3	10229.5	-9796.3	-2782.0
0.50	83642.7	16054.6	6944.3	-711.2
0.75	74622.0	21475.5	7507.7	3214.2
1.00	64770.4	21171.3	3820.9	2838.7
1.25	57891.2	20593.6	2202.8	2419.0
1.50	53766.7	19537.0	1524.5	2018.5
1.75	50321.1	18474.8	1089.5	1710.1
2.00	47948.2	17421.4	853.7	1448.0

TABLE XVIII. SHALLOW NOTCH FEA NONLINEAR 70,000lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS σ_θ ,psi	NO LOAD RESIDUALS σ_r ,psi
0.00	81957.9	704.5	-50670.6	63.9
0.25	82822.6	10668.8	-16176.6	-3285.1
0.50	84007.3	15514.4	-376.9	-2366.8
0.75	87017.4	22662.9	15132.6	2762.3
1.00	71318.0	23765.2	5681.1	3983.0
1.25	63762.9	23215.2	3763.1	3616.6
1.50	58941.5	21920.1	2669.9	3030.0
1.75	54897.6	20670.6	1865.4	2596.7
2.00	52177.0	19426.6	1448.2	2207.0

TABLE XIX. DEEP NOTCH FEA NONLINEAR 30,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS σ_θ ,psi	NO LOAD RESIDUALS σ_r ,psi
0.00	83521.0	2332.4	-14138.0	-725.2
0.25	58038.6	20971.3	5680.1	1402.5
0.50	43309.1	18640.5	385.7	824.6
0.75	34402.6	17839.1	198.3	468.9
1.00	30522.9	16076.1	125.0	300.5
1.25	27543.7	14574.8	88.9	215.3
1.50	25757.0	13328.7	67.3	160.7
1.75	24188.8	12195.0	53.5	126.3
2.00	23141.6	11265.7	44.9	100.9

TABLE XX. DEEP NOTCH FEA NONLINEAR 35,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS σ_θ ,psi	NO LOAD RESIDUALS σ_r ,psi
0.00	79020.4	1258.1	-39068.2	-1909.2
0.25	78215.7	24598.9	16348.7	1113.1
0.50	50094.6	22675.1	105.7	1699.5
0.75	40516.0	21359.5	624.1	1002.8
1.00	35843.1	19156.9	380.6	716.7
1.25	32290.3	17299.1	257.8	521.7
1.50	30172.9	15782.1	203.5	405.9
1.75	28314.8	14410.8	156.9	319.5
2.00	27079.2	13294.4	133.7	261.5

TABLE XXI. DEEP NOTCH FEA NONLINEAR 40,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS σ_θ ,psi	NO LOAD RESIDUALS σ_r ,psi
0.00	80929.5	835.4	-52900.9	-2121.6
0.25	89730.7	24933.8	20563.1	-2132.3
0.50	56572.6	26815.4	-610.4	2977.0
0.75	46984.6	24878.1	1468.2	1643.1
1.00	41400.6	22286.3	610.0	1216.6
1.25	37164.5	20068.3	555.9	892.7
1.50	34690.9	18287.2	438.5	710.5
1.75	32512.6	16672.2	330.7	564.8
2.00	31078.3	15368.8	282.0	470.8

TABLE XXII. RIGID - PERFECTLY - PLASTIC RESULTS

σ_y = 73,000 psi

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.00	73334.4	519.9
0.25	81780.5	20863.6
0.50	83252.6	29813.6
0.75	84074.1	37321.1
1.00	84103.1	40244.0
1.25	84091.8	42244.0
1.50	84051.5	43249.8
1.75	84005.0	44032.9
2.00	83958.1	43875.6

TABLE XXIII. EXPERIMENTAL DATA λ = 0.25 HOLE LINEAR LOADING

σ_∞ = 10,749 psi

DISTANCE FROM HOLE, in.	σ_θ ,psi	σ_r ,psi
0.000	35221.0	49.5
0.125	24639.0	-1650.5
0.250	19809.5	669.5
0.375	17799.0	2311.5
0.500	16588.0	3422.0

TABLE XXIV. EXPERIMENTAL DATA SHALLOW NOTCH LINEAR LOADING

15,000 lb Load

DISTANCE FROM HOLE, in.	σ_θ ,psi	σ_r ,psi
0.000	26611.7	53.2
0.125	22295.0	1392.6
0.250	19999.3	2352.7
0.375	17277.5	2387.6
0.500	15798.7	2880.5
0.625	13679.1	1929.3

TABLE XXV. EXPERIMENTAL DATA SHALLOW NOTCH 60,000 lb LOAD

DISTANCE FROM NOTCH,in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS	
			σ_θ ,psi	σ_r ,psi
0.000	81111.5	5551.0	-23842.0	4.0
0.125	79710.7	6735.8	-19837.0	-475.0
0.250	78112.0	8141.5	-16409.0	-1044.0
0.375	77189.3	11899.5	-12620.0	-1426.0
0.500	71207.2	10509.4	-12319.0	-5008.0
0.625	71436.4	19260.0	-10908.0	-6453.0
0.750	63045.8	16580.9		
0.875	59477.4	17748.6		
1.000	57146.4	19275.4		

TABLE XXVI. EXPERIMENTAL DATA SHALLOW NOTCH 65,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS	
			σ_θ ,psi	σ_r ,psi
0.000	83073.9	7058.0	-36745.0	-191.0
0.125	80957.6	6078.9	-32543.0	-387.0
0.250	79854.9	7468.1	-28256.0	-1554.0
0.375	79482.8	10878.9	-23914.0	-2381.0
0.500	79638.4	16634.0	-20192.0	-2686.0
0.625	77887.0	19867.6	-16300.0	-3392.0
0.750	72556.4	19706.7		
0.875	64863.2	17433.1		
1.000	61648.0	19034.1		

TABLE XXVII. EXPERIMENTAL DATA SHALLOW NOTCH 70,000 lb LOAD

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi	NO LOAD RESIDUALS	
			σ_θ ,psi	σ_r ,psi
0.000	84748.9	8569.0	-50791.0	43.0
0.125	83492.9	9073.9	-46086.0	-736.0
0.250	84258.3	13718.2	-40774.0	-878.0
0.375	82846.8	13815.0	-34600.0	-1016.0
0.500	82524.6	16814.9	-30017.0	-1316.0
0.625	80446.4	17441.6	-24798.0	-1551.0
0.750	80455.5	23190.4		
0.875	76568.9	22928.7		
1.000	72264.1	23604.0		

TABLE XXVIII. EXPERIMENTAL DATA DEEP NOTCH LINEAR LOADING

15,000 lb Load

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.000	45907.0	-45.0
0.125	35372.0	7693.0
0.250	30410.0	11671.0
0.375	26177.0	12395.0
0.500	20939.0	9879.0
0.625	18373.0	9060.0
0.750	16891.0	8984.0

TABLE XXIX. EXPERIMENTAL DATA DEEP NOTCH 30,000 lb LOAD

Elastic - Plastic

DISTANCE FROM NOTCH, in.	σ_θ ,psi	σ_r ,psi
0.000	76156.6	2587.4
0.125	63996.2	6057.7
0.250	50047.3	10456.3
0.375	43992.3	14485.8
0.500	39748.6	16433.6
0.625	35030.8	15899.3
0.750	33286.8	16728.0

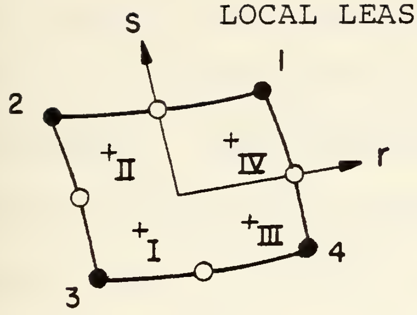
APPENDIX A

PSAP1 JCL

```
     ----- STANDARD JOB CARD -------
// EXEC FRTXCLGP
//FORT.SYSPRINT  DD  DUMMY
//FORT.SYSIN DD UNIT=3330,VOL=SER=DISK02,
// DSN=S2939.PSAP(PSAP),DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(PLOT),
// DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(INIT),
// DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(ELER),
// DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(SAPF),
// DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(ADNA),
// DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(AUXL),
// DISP=SHR,LABEL=(,,,IN)
// DD UNIT=3330,VOL=SER=DISK02,DSN=S2939.PSAP(ADPT),
// DISP=SHR,LABEL=(,,,IN)
// DD *
C *** MAIN PROGRAM ***
      DIMENSION ZZZ(3203),DISPD(5,3,800)
      CALL PSAP1(ZZZ,3203,DISPD,800)
      STOP
      END
************* DELIMITER CARD  (/*) ***************
//GO.FT10F001 DD UNIT=SYSDA,DISP=(,PASS),
// SPACE=(CYL,(2,2)),DSN=&&TEMP1
//GO.SYSIN DD *
**********************************************
*********  INSERT PSAP1 DATA HERE ***********
**********************************************
************* DELIMITER CARD  (/*) ***************
```

APPENDIX B

LOCAL LEAST SQUARES SMOOTHING



● Corner Nodes
o Midside Nodes
+ 2x2 Gauss Points

Two-Dimensional Isoparametric Element from ADINA [Ref. 4]

The local smoothing expression from Hinton and Campbell [Ref. 19] in ADINA coordinates becomes

$$\left\{\begin{matrix} \tilde{\sigma}_1 \\ \tilde{\sigma}_2 \\ \tilde{\sigma}_3 \\ \tilde{\sigma}_4 \end{matrix}\right\} = \begin{bmatrix} C & B & B & A \\ B & A & C & B \\ A & B & B & C \\ B & C & A & B \end{bmatrix} \times \left\{\begin{matrix} \sigma_I \\ \sigma_{II} \\ \sigma_{III} \\ \sigma_{IV} \end{matrix}\right\}$$

where $A = 1 + \frac{\sqrt{3}}{2}$, $B = -\frac{1}{2}$ and $C = 1 - \frac{\sqrt{3}}{2}$.

With $\tilde{\sigma}_1$, $\tilde{\sigma}_2$, $\tilde{\sigma}_3$ and $\tilde{\sigma}_4$ representing the smoothed corner node stresses and σ_I, σ_{II}, σ_{III}, and σ_{IV} as the unsmoothed stresses at the Gauss integration points, this expression can be written in an equivalent form.

$$\left\{\begin{matrix} \tilde{\sigma}_3 \\ \tilde{\sigma}_4 \\ \tilde{\sigma}_1 \\ \tilde{\sigma}_2 \end{matrix}\right\} = \begin{bmatrix} A & B & C & B \\ B & A & B & C \\ C & B & A & B \\ B & C & B & A \end{bmatrix} \times \left\{\begin{matrix} \sigma_I \\ \sigma_{III} \\ \sigma_{IV} \\ \sigma_{II} \end{matrix}\right\}$$

The midside node stress values may be obtained by averaging the values at the associated corner nodes, since the distribution of the smoothed stresses is linear along the sides of the element. Smoothed stress values obtained by this least squares method should subsequently be averaged to obtain unique values at nodal points shared by adjacent elements.

APPENDIX C

ADINA JCL

```
    ----- STANDARD JOB CARD -------
// EXEC FORTXCLG,REGION=2000K
//FORT.SYSPRINT DD DUMMY
//FORT.SYSIN DD *
     IMPLICIT REAL*8(A-H,O-Z)
     REAL A
     COMMON A(120010)
     MAX=120000
     CALL EXEC(MAX)
     STOP
     END
************* DELIMITER CARD  (/*) ***************
//LKED.USDD DD DISP=SHR,DSN=MSS.S2939.ADINA
//LKED.SYSIN DD *
  INCLUDE USDD(LOADM)
  ENTRY MAIN
************* DELIMITER CARD  (/*) ***************
//GO.FT07F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=4000),SPACE=(CYL,(5,1))
//GO.FT01F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=4000),SPACE=(CYL,(5,1))
//GO.FT02F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=4000),SPACE=(CYL,(5,1))
//GO.FT03F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=1000),SPACE=(CYL,(5,1))
//GO.FT04F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=1000),SPACE=(CYL,(5,1))
//GO.FT08F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=4000),SPACE=(CYL,(5,1))
//GO.FT09F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=4000),SPACE=(CYL,(5,1))
//GO.FT10F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=4000),SPACE=(CYL,(5,1))
//GO.FT11F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=1000),SPACE=(CYL,(5,1))
//GO.FT12F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=1000),SPACE=(CYL,(5,1))
//GO.FT13F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=1000),SPACE=(CYL,(5,1))
//GO.FT56F001 DD UNIT=3330,VOL=SER=DISK01,
// DSN=F0099.TEMP,DISP=SHR,LABEL=(,,,IN)
//GO.FT57F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
//   DCB=(RECFM=VBS,BLKSIZE=1000),SPACE=(CYL,(5,1))
//GO.SYSIN DD *
*************************************
********** INSERT ADINA DATA HERE ***********
*************************************
    --- BLANK CARD ----
    --- BLANK CARD ---     (TWO BLANK CARDS STOP EXEC)
************* DELIMITER CARD  (/*) ***************
```

APPENDIX D

PSAP1 LISTING

```
C          PSAP1        MAR 1981  AS MODIFIED BY LCDR M.J. KAISER       APR1981
C                                                                       DOCU0020
C                                                                       DOCU0030
C    SUBROUTINE PSAP1 DOCUMENTATION                                     DOCU0040
C                                                                       DOCU0050
C                                                                       DOCU0060
C                                                                       DOCU0070
C                       DESCRIPTION OF INPUT DATA CARDS                 DOCU0080
C                                                                       DOCU0090
C                                                                       DOCU0100
C                                                                       DOCU0110
C    TITLE CARD - 80 ALPHANUMERIC CHARACTERS OF GRAPH TITLE INFORMATION DOCU0120
C                 TO BE PRINTED ABOVE AND BELOW THE GRAPH. THE FIRST 40 DOCU0130
C                 CHARACTERS WILL FORM THE FIRST TITLE LINE. THE LAST 40DOCU0140
C                 THE SECOND LINE.                                      DOCU0150
C                                                                       DOCU0160
C                                                                       DOCU0170
C    NAMELIST OPTION - CONTAINS VALUES TO VERIFY STORAGE IN BLANK       DOCU0180
C                      COMMON AND CONTROL VALUES NEEDED BY THE PROGRAM. DOCU0190
C                                                                       DOCU0200
C        THE FOLLOWING VALUES ARE INCLUDED---                           DOCU0210
C                                                                       DOCU0220
C        NNDEST = ESTIMATE NUMBER OF GRID POINTS TO BE USED.  VALUE MUSTDOCU0230
C                 BE GREATER THAN OR EQUAL TO THE ACTUAL NUMBER OF GRID DOCU0240
C                POINTS.                                                DOCU0250
C             ** DEFAULT = 200 **                                       DOCU0260
C        NUDISP = 0 FOR NO DISPLACEMENT DATA IN X-DIRECTION.            DOCU0270
C               = 1 FOR DATA INCLUDING DISPLACEMENTS IN X-DIRECTION.    DOCU0280
C             ** DEFAULT = 0 **                                         DOCU0290
C        NVDISP = 0 FOR NO DISPLACEMENT DATA IN Y-DIRECTION.            DOCU0300
C               = 1 FOR DATA INCLUDING DISPLACEMENTS IN Y-DIRECTION.    DOCU0310
C             ** DEFAULT = 0 **                                         DOCU0320
C        NWDISP = 0 FOR NO DISPLACEMENT DATA IN Z-DIRECTION.            DOCU0330
C               = 1 FOR DATA INCLUDING DISPLACEMENTS IN Z-DIRECTION.    DOCU0340
C             ** DEFAULT = 0 **                                         DOCU0350
C                                                                       DOCU0360
C        KGEOM SPECIFIES SUBROUTINE AND CORRESPONDING METHOD OF INPUT   DOCU0370
C        FOR MODEL GEOMETRY.                                            DOCU0380
C        KGEOM = 1 FOR USER SUPPLIED SUBROUTINE - GEOM1                 DOCU0390
C                  GEOM1 DEVELOPED TO READ ADINA GEOMETRY DATA - MAR 77 DOCU0400
C              = 2 FOR USER SUPPLIED SUBROUTINE - GEOM2                 DOCU0410
C              = 9 FOR SAP IV DATA DECK INPUT SUBROUTINE - GEOM9.       DOCU0420
C                  GEOM9 READS SAP IV GEOMETRY DATA - MODIFIED  MAR 77  DOCU0430
C             ** DEFAULT = 9 **                                         DOCU0440
C        KDATA SPECIFIES SUBROUTINE AND CORRESPONDING METHOD OF INPUT   DOCU0450
C        FOR DISPLACEMENT DATA.                                         DOCU0460
C        KDATA = 1 FOR SUBROUTINE DATA1 TO READ IN DISPLACEMENT DATA    DOCU0470
C                 -- SUPPLIED BY THE USER.                              DOCU0480
```

```
C              = 5 FOR SUBROUTINE DATA5 TO READ IN DISPLACEMENT DATA    DOCU0490
C                  -- SUPPLIED BY THE USER.                             DOCU0500
C              = 9 FOR SUBROUTINE DATA9 TO READ SAP IV DATA.            DOCU0510
C             ** DEFAULT = 9 **                                         DOCU0520
C       NVALUS - NOT USED AT NPS ----- ALLOW DEFAULT                    DOCU0530
C                                                                       DOCU0540
C             ** DEFAULT = 0 **                                         DOCU0550
C         IRESEQ - NOT USED AT NPS ----- ALLOW TO DEFAULT               DOCU0560
C             ** DEFAULT = 1 **                                         DOCU0570
C        KPLOT SPECIFIES THE TYPE OF OUTPUT DEVICE TO BE USED.          DOCU0580
C        KPLOT = 1 FOR CALCOMP.                                         DOCU0590
C              = 2 FOR LANGLEY RESEARCH CENTER USE ONLY                 DOCU0600
C              = 3 FOR LRC USE ONLY.                                    DOCU0610
C              = 4 FOR   LRC USE ONLY                                   DOCU0620
C             ** DEFAULT = 1 **                                         DOCU0630
C       YSPACE = SPACE BETWEEN PLOTS IN Y DIRECTION (INCHES) WHEN       DOCU0640
C                 MULTIPLE PLOTS ARE PRODUCED. YSPACE/2.0 IS SPACE      DOCU0650
C                 BETWEEN TITLE BLOCK AND PLOT.                         DOCU0660
C             ** DEFAULT = 2.0 **                                       DOCU0670
C        PSIZE  =  PAPER SIZE IN X DIRECTION, USED IN SCALING OF        DOCU0680
C                  PLOTS TO INSURE THIS DIMENSION IS NOT EXCEEDED.      DOCU0690
C             ** DEFAULT = 9.0 **                                       DOCU0700
C        IDCASE = 0 FOR NO TITLE CARD PRECEDING                         DOCU0710
C                   DECKS OF DISPLACEMENT VALUES.                       DOCU0720
C               = 1 FOR TITLE CARD PRECEDING                            DOCU0730
C                   DECKS OF DISPLACEMENT VALUES.                       DOCU0740
C             ** DEFAULT = 0 **                                         DOCU0750
C                                                                       DOCU0760
C                                                                       DOCU0770
C                                                                       DOCU0780
C    MODEL GEOMETRY IS NOW INPUT IN ONE OF THE FOLLOWING FORMS,         DOCU0790
C       DEPENDING ON THE VALUE OF KGEOM SPECIFIED IN NAMELIST OPTION.   DOCU0800
C                                                                       DOCU0810
C                                                                       DOCU0820
C     USE IF KGEOM = 1                                                  DOCU0830
C       CALL SUBROUTINE GEOM1 WHICH READS ADINA GEOMETRY DATA           DOCU0840
C                                                                       DOCU0850
C     USE IF KGEOM = 2                                                  DOCU0860
C       CALL SUBROUTINE GEOM2 WHICH IS PREPARED BY THE USER TO          DOCU0870
C       READ GEOMETRY DATA.                                             DOCU0880
C                                                                       DOCU0890
C                                                                       DOCU0900
C                                                                       DOCU0910
C     USE IF KGEOM = 9                                                  DOCU0920
C                                                                       DOCU0930
C        CALL SUBROUTINE GEOM9 WHICH READS SAP IV GEOMETRY DATA.        DOCU0940
C                                                                       DOCU0950
C                                                                       DOCU0960
```

```
C                                                                       DOCU0970
C    CASE IDENTIFICATION CARD.                                          DOCU0980
C                                                                       DOCU0990
C        THIS CARD IS OMITTED IF IDCASE=0 IS SPECIFIED IN &OPTION       DOCU1000
C        IF PRESENT, THIS CARD CONTAINS ANY DESIRED ALPHANUMERIC        DOCU1010
C        INFORMATION IN COLS.1-80 WILL NOT APPEAR ON PLOT BUT WILL      DOCU1020
C        APPEAR ON PRINTOUT ABOVE DISPLACEMENT DATA                     DOCU1030
C                                                                       DOCU1040
C                                                                       DOCU1050
C    DATA TO BE PLOTTED IS NOW INPUT IN ONE OF THE FOLLOWING FORMS,     DOCU1060
C        DEPENDING ON THE VALUE OF KDATA SPECIFIED IN NAMELIST OPTION.  DOCU1070
C                                                                       DOCU1080
C                                                                       DOCU1090
C      USE IF KDATA = 1                                                 DOCU1100
C        CALL SUBROUTINE DATA1 WHICH IS PREPARED BY THE USER            DOCU1110
C                                                                       DOCU1120
C                                                                       DOCU1130
C                                                                       DOCU1140
C      USE IF KDATA = 5                                                 DOCU1150
C        CALL SUBROUTINE DATA5 WHICH IS PREPARED BY THE USER            DOCU1160
C                                                                       DOCU1170
C                                                                       DOCU1180
C      USE IF KDATA = 9                                                 DOCU1190
C                                                                       DOCU1200
C        CALL SUBROUTINE DATA9 WHICH READS SAP IV DISPLACEMENT DATA.    DOCU1210
C        A DISPLACEMENT DATA DECK CAN BE PREPAIRED FOR ADINA IN A       DOCU1220
C        FORMAT COMPATABLE WITH DATA9.                                  DOCU1230
C                                                                       DOCU1240
C                                                                       DOCU1250
C                                                                       DOCU1260
C                                                                       DOCU1270
C     NAMELIST PICT - CONTAINS VALUES NEEDED TO GENERATE PLOTS.         DOCU1280
C                                                                       DOCU1290
C        THE FOLLOWING VALUES ARE INCLUDED---                           DOCU1300
C                                                                       DOCU1310
C        KHORZ = INTEGER DESIGNATING HORIZONTAL AXIS OF VIEWING PLANE,  DOCU1320
C                WHERE 1=X, 2=Y, 3=Z.                                   DOCU1330
C             ** DEFAULT = 1 **                                         DOCU1340
C        KVERT = INTEGER DESIGNATING VERTICAL AXIS OF VIEWING PLANE,    DOCU1350
C                WHERE 1=X, 2=Y, 3=Z.                                   DOCU1360
C             ** DEFAULT = 2 **                                         DOCU1370
C        PHI = ANGULAR ROTATION OF MODEL ABOUT ITS X-AXIS, IN DEGREES   DOCU1380
C              (MUST BE TAKEN THIRD).                                   DOCU1390
C             ** DEFAULT = 0.0 **                                       DOCU1400
C        THETA = ANGULAR ROTATION OF MODEL ABOUT ITS Y-AXIS, IN DEGREES DOCU1410
C                (MUST BE TAKEN SECOND).                                DOCU1420
C             ** DEFAULT = 0.0 **                                       DOCU1430
C        PSI = ANGULAR ROTATION OF MODEL ABOUT ITS Z-AXIS, IN DEGREES   DOCU1440
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C          (MUST BE TAKEN FIRST).                                      DOCU1450
C         ** DEFAULT = 0.0 **                                          DOCU1460
C      NEWFR = 1 FOR FRAME CHANGE BEFORE PLOT IS MADE.                 DOCU1470
C              (A FRAME CHANGE RESETS THE Y-ORIGIN PAST PREVIOUS PLOTDOCU1480
C               BY YSPACE AND X-ORIGIN AT 0.0)                         DOCU1490
C               NEWFR.NE.1 FOR NO FRAME CHANGE BEFORE PLOTTING         DOCU1500
C         ** DEFAULT = 1 **                                            DOCU1510
C      ISCALE = 1 FOR INTERNAL ORIGIN LOCATION AND SCALING.            DOCU1520
C             = 2 FOR USER SPECIFIED ORIGIN AND SCALING.               DOCU1530
C             = 0 FOR NO SCALE CHANGE.(I.E. USE SAME SCALE AS PREVIOUSDOCU1540
C              PLOT) THIS IS USEFUL IN AN ASSEMBLY GRAPH WHERE IT IS DOCU1550
C              NECESSARY TO EXAMINE A MESH IN SECTIONS WITHOUT LOSINGDOCU1560
C              PERSPECTIVE. ISCALE CANNOT BE ZERO ON THE FIRST PLOT. DOCU1570
C         ** DEFAULT = 1 **                                            DOCU1580
C      PLOTSZ = MAXIMUM DIMENSION DESIRED ON COMPLETED PLOT.           DOCU1590
C              (USED FOR SCALING IF ISCALE = 1)                        DOCU1600
C              PLOTSZ SCALES THE PLOT PRIOR TO ROTATION. IF ROTATION DOCU1610
C              CAUSES THE PLOT TO EXCEED PAPER WIDTH (PSIZE), IT IS  DOCU1620
C              RESCALED AND THE PLOT SIZE IS REDUCED ACCORDINGLY.    DOCU1630
C         ** DEFAULT = 10.0 **                                         DOCU1640
C      XORGN = X-LOCATION OF PLOT ORIGIN (USED IF ISCALE = 2).         DOCU1650
C         ** DEFAULT = 0.0 **                                          DOCU1660
C      YORGN = Y-LOCATION OF PLOT ORIGIN (USED IF ISCALE = 2).         DOCU1670
C         ** DEFAULT = 0.0 **                                          DOCU1680
C      PSCALE = MODEL SIZE REDUCTION FACTOR, PSCALE = ACTUAL MODEL     DOCU1690
C              SIZE/DESIRED PLOT SIZE (USED IF ISCALE = 2).            DOCU1700
C         ** DEFAULT = 1.0 **                                          DOCU1710
C      NOTAT = 0 FOR NO NUMBERING ON PLOTS.                            DOCU1720
C            = 1 FOR NUMBERING OF GRID POINTS.                         DOCU1730
C            = 2 FOR NUMBERING OF ELEMENTS.                            DOCU1740
C         ** DEFAULT = 0 **                                            DOCU1750
C      XLHT = HEIGHT OF INTEGERS SPECIFIED BY NOTAT, IN INCHES.        DOCU1760
C         ** DEFAULT = 0.15 **                                         DOCU1770
C      KDISP = 0 FOR UNDEFORMED PLOT.                                  DOCU1780
C            = 1 FOR DEFORMED PLOT.                                    DOCU1790
C            = 2 FOR EXPLODED PLOT.                                    DOCU1800
C            = 3 FOR DISPLACEMENTS REPRESENTED BY VECTORS.             DOCU1810
C         ** DEFAULT = 0 **                                            DOCU1820
C      IDMAG = 1 FOR DIRECT SCALING OF DATA BY DMAGS.                  DOCU1830
C            = 2 FOR SCALING OF DATA TO A MAX. VALUE OF DMAGS.         DOCU1840
C         ** DEFAULT = 2 **                                            DOCU1850
C      DMAGS = MAGNIFICATION OF DISPLACEMENTS (IF KDISP=1).            DOCU1860
C            = REDUCTION FACTOR OF ELEMENTS (IF KDISP=2).              DOCU1870
C         ** DEFAULT = 1.0 **                                          DOCU1880
C      KSYMXY = 1 FOR SYMMETRY ABOUT X-Y PLANE.                        DOCU1890
C         ** DEFAULT = 0 **                                            DOCU1900
C      KSYMXZ = 1 FOR SYMMETRY ABOUT X-Z PLANE.                        DOCU1910
C         ** DEFAULT = 0 **                                            DOCU1920
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C        KSYMYZ = 1 FOR SYMMETRY ABOUT Y-Z PLANE.                       DOCU1930
C             ** DEFAULT = 0 **                                         DOCU1940
C        XXMAX,YYMAX,ZZMAX,XXMIN,YYMIN,ZZMIN LOCATE CUTTING PLANES      DOCU1950
C             PARALLEL TO PRINCIPAL (X-Y,X-Z,Y-Z) PLANES                DOCU1960
C             TO LIMIT PLOT.                                            DOCU1970
C             ** DEFAULT XXMAX=YYMAX=ZZMAX=1.0E+20 **                   DOCU1980
C             ** DEFAULT XXMIN=YYMIN=ZZMIN=-1.0E+20 **                  DOCU1990
C        NDMAX = MAXIMUM GRID PT. TO BE INCLUDED IN PLOT.               DOCU2000
C             ** DEFAULT = 9999999999 **                                DOCU2010
C        NDMIN = MINIMUM GRID PT. TO BE INCLUDED IN PLOT.               DOCU2020
C             ** DEFAULT = 0 **                                         DOCU2030
C        NELMAX = MAXIMUM ELEMENT NUMBER TO BE INCLUDED IN PLOT.        DOCU2040
C             ** DEFAULT = 9999999999 **                                DOCU2050
C        NELMIN = MINIMUM ELEMENT NUMBER TO BE INCLUDED IN PLOT.        DOCU2060
C             ** DEFAULT = 0 **                                         DOCU2070
C        KODE SPECIFIES CONTROL OPTION AFTER PLOT IS COMPLETE.          DOCU2080
C        KODE = 0, LAST PLOT, EXIT FROM PROGRAM.                        DOCU2090
C             = 1, READ ANOTHER NAMELIST PICT.                          DOCU2100
C             = 2, READ A NEW SET OF DISPLACEMENT DATA, INCLUDING A     DOCU2110
C                  CASE IDENTIFICATION CARD IF PRESENT.                 DOCU2120
C             = 3, READ A COMPLETE NEW SET OF INPUT DATA,               DOCU2130
C                  INCLUDING A TITLE CARD.                              DOCU2140
C             ** DEFAULT = 0 **                                         DOCU2150
C                                                                       DOCU2160
C                                                                       DOCU2170
C                                                                       DOCU2180
C   THE ABOVE COMPRISES A COMPLETE BASIC SET OF INPUT DATA IF           DOCU2190
C   KODE = 0 IN &PICT.  FOR KODE = 1, 2, OR 3, ADDITIONAL SECTIONS OF   DOCU2200
C   THE BASIC DECK MUST BE REPEATED.  THE DECK MUST END WITH            DOCU2210
C   NAMELIST &PICT HAVING KODE = 0.                                     DOCU2220
C                                                                       DOCU2230
C                                                                       DOCU2240
C***********************************************************************DOCU2400
C                                                                       DOCU2410
C                                                                       DOCU2420
C                                                                       DOCU2430
C        SUBROUTINE PSAP1 IS A MODIFICATION TO NAVAL POSTGRADUATE       DOCU2440
C        SCHOOL THESIS BY LT. D. M. LOSH , DECEMBER 1976.  MODIFICATION DOCU2450
C        INCLUDED SAP IV 8-21 NODE BRICK ELEMENTS,BOUNDARY ELEMENTS AND DOCU2460
C        ADINA TRUSS,PLANE,BRICK ,BEAM ELEMENTS,AND OTHER MINOR         DOCU2470
C        IMPROVEMENTS.                                                  DOCU2480
C                                                                       DOCU2490
C                                                                       DOCU2500
C     MODIFIED BY  ADRIAN E. KIBLER JR.                                 DOCU2510
C                  LT              USN                                  DOCU2520
C                  NAVAL POSTGRADUATE SCHOOL                            DOCU2530
C                  MONTEREY,CA.                                         DOCU2540
C                  JAN - JUN 1977                                       DOCU2550
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C                                                                       DOCU2560
C                                                                       DOCU2570
C***********************************************************************APR1981
C                                                                       APR1981
C                                                                       APR1981
C               ISOLATED GRAPHICS PLOTTING SUBROUTINES                  APR1981
C                                                                       APR1981
C         THE SUBROUTINES USED IN THE ACTUAL CREATION OF PLOTS BY       APR1981
C         THE VERSATEC MODEL 8222A ARE EXPLAINED IN NPS TECHNICAL NOTE  APR1981
C         NUMBER 0141-34,"USING VERSATEC PLOTTER AT NPS".               APR1981
C                                                                       APR1981
C            PSAP1 SJBROUTINES WITH VERSATEC CALL STATEMENTS:           APR1981
C                                                                       APR1981
C              CALCMP      CALPLT      CALNUM      NOTATE               APR1981
C                                                                       APR1981
C              CALWH       CALINE      PSTOP                            APR1981
C                                                                       APR1981
C                                                                       APR1981
C                                                                       APR1981
C  *** ADAPTED FOR VERSATEC BY LCDR MICHAEL J KAISER, JAN 1981 ***      APR1981
C                                                                       APR1981
C                                                                       APR1981
C                                                                       APR1981
C***********************************************************************APR1981
C  ################################################################     APR1981
C  #                                                              #     APR1981
C  #                                                              #     APR1981
C  #     EXAMPLE OF MAIN PROGRAM USED TO ALLOCATE CORE STORAGE    #     APR1981
C  #      SPACE REQUIRED AND CALL PSAP1:                          #     APR1981
C  #                                                              #     APR1981
C  #          DIMENSION ZZZ(NZ),DISPD(5,3,NON)                    #     APR1981
C  #          CALL PSAP1(ZZZ,NZ,DISPD,NON)                        #     APR1981
C  #          STOP                                                #     APR1981
C  #          END                                                 #     APR1981
C  #                                                              #     APR1981
C  #     WHERE:                                                   #     APR1981
C  #                                                              #     APR1981
C  #          NON---MUST BE GREATER THAN NUMBER OF NODES          #     APR1981
C  #                                                              #     APR1981
C  #          NZ----MUST BE GREATER THAN  4 * NON + 3             #     APR1981
C  #               (7*NON+3 IF DISPLACEMENT DATA IS INPUT)        #     APR1981
C  #                                                              #     APR1981
C  #                                                              #     APR1981
C  ################################################################     APR1981
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      SUBROUTINE PSAP1(ZZZ,NZ,DISPD,NON)                                PSAP0010
C                                                                       PSAP0020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PSAP0030
C                                                                       PSAP0040
C                                                                       PSAP0050
C *** THIS IS THE MAIN SUBROUTINE WHICH CALLS OTHER SUBROUTINES         PSAP0060
C                                                                       PSAP0070
C                                                                       PSAP0080
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PSAP0090
C                                                                       PSAP0100
      INTEGER NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT                             PSAP0110
      COMMON/CDATA/NTIME,NTLC                                           PSAP0120
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PSAP0130
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PSAP0140
     2PSCALE,KDISP,DMAG,KODE                                            PSAP0150
      COMMON/LIMITS/ XXMAX,YYMAX,ZZMAX,XXMIN,YYMIN,ZZMIN,NDMAX,NDMIN,   PSAP0160
     1NELMAX,NELMIN                                                     PSAP0170
      COMMON/CORGN/ YPMAX,YSPACE,PSIZE                                  PSAP0180
      COMMON/GLOOP/ ILOOP                                               PSAP0190
      COMMON/ABLK/ A(3,3)                                               PSAP0200
      COMMON/SAVEV/ DMAGS,IDMAG                                         PSAP0210
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   PSAP0220
      COMMON/VALUES/ NVALUS                                             PSAP0230
      COMMON/CASEID/ IDCASE                                             PSAP0240
      DIMENSION ZZZ(NZ),DISPD(5,3,NON),ABCD1(10),ABCD2(10),ABCD3(10),   PSAP0250
     1ABCD4(10)                                                         PSAP0260
      NAMELIST/PICT/ KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,            PSAP0270
     1PLOTSZ,XORGN,YORGN,PSCALE,NOTAT,KDISP,IDMAG,DMAGS,KODE,           PSAP0280
     2KSYMXY,KSYMXZ,KSYMYZ, XXMAX,YYMAX,ZZMAX,XXMIN,                    PSAP0290
     3YYMIN,ZZMIN,NDMAX,NDMIN,NELMAX,NELMIN,XLHT                        PSAP0300
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```
C                                                                       PSAP0310
C *** TO ZERO NODE AND ELEMENT SJMMATION COUNTERS                        PSAP0320
C                                                                       PSAP0330
      ILOOP = 0                                                         PSAP0340
      NNODE = 0                                                         PSAP0350
      YPMAX=0.0                                                         PSAP0360
C                                                                       PSAP0370
C *** TO DEFINE THE 3RIGIN AND OPEN PLOTING DATA SETS                   PSAP0380
C                                                                       PSAP0390
      CALL CALCMP                                                       APR1981
  500 CONTINUE                                                          PSAP0410
      REWIND 10                                                         PSAP0420
      WRITE(6,8)                                                        PSAP0430
    8 FORMAT(1H1)                                                       PSAP0440
C                                                                       PSAP0450
C *** TO READ TITLE CARD FOR RUN                                        PSAP0460
C                                                                       PSAP0470
      READ(5,9004,EN3=999) (ABCD1(I),I=1,10),(ABCD2(I),I=1,10)          PSAP0480
 9004 FORMAT(20A4)                                                      PSAP0490
      WRITE(6,9006) (ABCD1(I),I=1,10),(ABCD2(I),I=1,10)                 PSAP0500
 9006 FORMAT (///,20X,20A4////)                                         PSAP0510
      CALL INITAL                                                       PSAP0520
C                                                                       PSAP0530
C *** TO PLOT THE TITLE CARD AT THE BEGINING OF THE PLOT                PSAP0540
C                                                                       PSAP0550
      CALL CALPLT(0.0,0.62,3)                                           APR1981
      CALL CALPLT(0.0,0.0,2)                                            APR1981
      CALL CALPLT(9.0,0.0,2)                                            APR1981
      CALL NOTATE(0.8,0.41,0.21,ABCD1,0.0,40)                           APR1981
      CALL NOTATE(0.8,0.10,0.21,ABCD2,0.0,40)                           APR1981
      CALL CALPLT(0.3,1.62+YSPACE/2.0,-3)                               APR1981
C                                                                       PSAP0630
C *** TO SET POINTERS FOR BLANK COMMON STORAGE ZZZ                      PSAP0640
C *** (WITH INTEGER NAMES OF ARRAYS USED IN CALLED SUBROUTINES)         PSAP0650
C                                                                       PSAP0660
      NUMPT = 1                                                         PSAP0670
      XPT = NUMPT+NN3EST                                                PSAP0680
      YPT = XPT+NNDEST                                                  PSAP0690
      ZPT = YPT+NNDEST                                                  PSAP0700
      UPT = ZPT+NNDEST                                                  PSAP0710
      IF(NUDISP.EQ.0) VPT = UPT+1                                       PSAP0720
      IF(NUDISP.NE.3) VPT = UPT+NNDEST                                  PSAP0730
      IF(NVDISP.EQ.0) WPT = VPT+1                                       PSAP0740
      IF(NVDISP.NE.3) WPT = VPT+NNDEST                                  PSAP0750
      IF(NWDISP.EQ.0) NEND = WPT+1-1                                    PSAP0760
      IF(NWDISP.NE.3) NEND = WPT+NNDEST-1                               PSAP0770
      WRITE(6,15) NEND                                                  PSAP0780
   15 FORMAT(///,20X,'BLANK COMMON STORAGE ZZZ REQUIRES AT LEAST ',I6,  PSAP0790
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     1' LOCATIONS FOR THIS CASE'///)                                    PSAP0800
      IF(KGEOM.EQ.1) CALL GEOM1                                         PSAP0810
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP0820
      IF(KGEOM.EQ.2) CALL GEOM2                                         PSAP0830
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP0840
      IF(KGEOM.EQ.9) CALL GEOM9                                         PSAP0850
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP0860
      CALL PNTOUT(1,                                                    PSAP0870
     1ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT)) PSAP0880
  600 CONTINUE                                                          PSAP0890
      IF(IDCASE.EQ.0) GO TO 650                                         PSAP0900
      READ(5,9004,END=999) (ABCD3(I),I=1,10),(ABCD4(I),I=1,10)          PSAP0910
      WRITE(6,9006) (ABCD3(I),I=1,10),(ABCD4(I),I=1,10)                 PSAP0920
  650 CONTINUE                                                          PSAP0930
      CALL ZEROD                                                        PSAP0940
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP0950
      IF(KDATA.EQ.1) CALL DATA1                                         PSAP0960
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP0970
      IF(KDATA.EQ.5) CALL DATA5                                         PSAP0980
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP0990
      IF(KDATA.EQ.9) CALL DATA9                                         PSAP1000
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT),PSAP1010
     2DISPD,VON)                                                        PSAP1020
      IF (NUDISP.EQ.0.AND.NVDISP.EQ.0.AND.NWDISP.EQ.0) GO TO 700        PSAP1030
      CALL PNTOUT(2,                                                    PSAP1040
     1ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT)) PSAP1050
  700 CONTINUE                                                          PSAP1060
      IF(KPLOT.EQ.4.AND.ILOOP.NE.0) GO TO 6000                          PSAP1070
      WRITE (6,1000)                                                    PSAP1080
 1000  FORMAT(///)                                                      PSAP1090
      READ(5,PICT)                                                      PSAP1100
      WRITE(6,PICT)                                                     PSAP1110
 6000 CONTINUE                                                          PSAP1120
      CALL DSCALE                                                       PSAP1130
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP1140
      CALL BOUND                                                        PSAP1150
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP1160
      IF(ISCALE.NE.0) CALL ROTAT                                        PSAP1170
      CALL PLOTX                                                        PSAP1180
     1(ZZZ(NUMPT),ZZZ(XPT),ZZZ(YPT),ZZZ(ZPT),ZZZ(UPT),ZZZ(VPT),ZZZ(WPT))PSAP1190
      ILOOP=ILOOP+1                                                     PSAP1200
      GO TO (700,600),KODE                                              PSAP1210
C                                                                       PSAP1220
C *** TO PLOT TITLE ON TOP OF GRAPH IF KODE = 3                         PSAP1230
C *** TO PLOT TITLE ON TOP AND CLOSE PLOTING DATA SETS IF KODE = 0      PSAP1240
C                                                                       PSAP1250
      CALL CALPLT(0.0,YPMAX+YSPACE/2.0,-3)                              APR1981
      CALL CALPLT(0.0,1.0,3)                                            APR1981
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      CALL CALPLT(0.0,1.62,2)                                           APR1981
      CALL CALPLT(9.0,1.62,2)                                           APR1981
      CALL NOTATE(0.8,1.31,.21,ABCD1,0.0,40)                            APR1981
      CALL NOTATE(0.8,1.0,.21,ABCD2,0.0,40)                             APR1981
      CALL CALPLT(0.0,1.62+YSPACE,-3)                                   APR1981
      ILOOP=0                                                           PSAP1340
      IF(KODE.EQ.3) GO TO 500                                           PSAP1350
      WRITE(6,9008)                                                     PSAP1360
 9008 FORMAT(//,5X,'TERMINATION NORMAL DUE TO KODE = 0')                PSAP1370
      CALL PSTOP                                                        APR1981
      RETURN                                                            PSAP1390
  999 CALL ERROR(2)                                                     PSAP1400
      RETURN                                                            PSAP1410
      END                                                               PSAP1420
      SUBROUTINE PLOTX(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                   PLOT0010
C                                                                       PLOT0020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT0030
C                                                                       PLOT0040
C *** FOR GENERATING PLOTS.                                             PLOT0050
C *** CALLED BY PSAP1                                                   PLOT0060
C                                                                       PLOT0070
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT0080
C                                                                       PLOT0090
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PLOT0100
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PLOT0110
     2PSCALE,KDISP,DMAG,KODE                                            PLOT0120
      COMMON/LIMITS/ XXMAX,YYMAX,ZZMAX,XXMIN,YYMIN,ZZMIN,NDMAX,NDMIN,   PLOT0130
     1NELMAX,NELMIN                                                     PLOT0140
      COMMON/XYZLIM/ XYZMAX(3),XYZMIN(3)                                PLOT0150
      COMMON/CORGN/ YPMAX,YSPACE,PSIZE                                  PLOT0160
      COMMON/GLOOP/ ILOOP                                               PLOT0170
      COMMON/ABLK/ A(3,3)                                               PLOT0180
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   PLOT0190
      COMMON/PDELS/ DELX,DELY                                           PLOT0200
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      PLOT0210
      DIMENSION NODE(20),X(20),Y(20),Z(20),XDISP(20),YDISP(20),         PLOT0220
     1ZDISP(20),XROT(20),YROT(20),XP(23),YP(23)                         PLOT0230
C                                                                       PLOT0240
C *** TO MAKE ALL GRID POINT NUMBERS NEGATIVE                           PLOT0250
C                                                                       PLOT0260
      DO 50 I=1,NNODE                                                   PLOT0270
      IF(NUMPT(I).GT.0) NUMPT(I)=-NUMPT(I)                              PLOT0280
   50 CONTINUE                                                          PLOT0290
C                                                                       PLOT0300
C *** TO MAKE FRAME CHANGE IF NEWFR = 1                                 PLOT0310
C ***     NO FRAME CHANGE ON FIRST PLOT AFTER NAMELIST OPTION           PLOT0320
C                                                                       PLOT0330
      YMOVE=0.0                                                         PLOT0340
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      IF(ILOOP.EQ.0) GO TO 70                                           PLOT0350
      IF(NEWFR.EQ.1) YMOVE=YPMAX+YSPACE                                 PLOT0360
   70 CALL CALPLT(0.0,YMOVE,-3)                                         APR1981
      GO TO (710,710,703,710),KPLOT                                     PLOT0380
  703 CONTINUE                                                          PLOT0390
C                                                                       APR1981
  710 CONTINUE                                                          PLOT0410
      IF(ISCALE.NE.0) DELX=0.0                                          PLOT0420
      IF(ISCALE.NE.0) DELY=0.0                                          PLOT0430
      IF(ISCALE.EQ.1) CALL XYSCAL                                       PLOT0440
      CALL CALPLT(XORGN,YORGN,-3)                                       APR1981
      XSHIFT = 0.0                                                      PLOT0460
      YSHIFT = 0.0                                                      PLOT0470
      ZSHIFT = 0.0                                                      PLOT0480
      YPMAX=-1.0E20                                                     PLOT0490
C                                                                       PLOT0500
C *** LOOPS TO ACCOUNT FOR SYMMETRY                                     PLOT0510
C                                                                       PLOT0520
      ZSIGN = +1.0                                                      PLOT0530
      DO 500 II=1,2                                                     PLOT0540
      IF(II.EQ.2.AND.KSYMXY.NE.1) GO TO 500                             PLOT0550
      IF(II.EQ.2.AND.KSYMXY.EQ.1) ZSIGN = -1.0                          PLOT0560
      YSIGN = +1.0                                                      PLOT0570
      DO 510 JJ=1,2                                                     PLOT0580
      IF(JJ.EQ.2.AND.KSYMXZ.NE.1) GO TO 510                             PLOT0590
      IF(JJ.EQ.2.AND.KSYMXZ.EQ.1) YSIGN = -1.0                          PLOT0600
      XSIGN = +1.0                                                      PLOT0610
      DO 520 KK=1,2                                                     PLOT0620
      IF(KK.EQ.2.AND.KSYMYZ.NE.1) GO TO 520                             PLOT0630
      IF(KK.EQ.2.AND.KSYMYZ.EQ.1) XSIGN = -1.0                          PLOT0640
C                                                                       PLOT0650
C *** TO DETERMINE PROJECTED COORDINATES OF ELEMENTS                    PLOT0660
C                                                                       PLOT0670
      REWIND 10                                                         PLOT0680
  100 CONTINUE                                                          PLOT0690
      READ(10,END=1000) NEND,NUMEL,(NODE(J),J=1,NEND)                   PLOT0700
      IF(NUMEL.LT.NELMIN.OR.NUMEL.GT.NELMAX) GO TO 100                  PLOT0710
      DO 10 I=1,NEND                                                    PLOT0720
      ND = NODE(I)                                                      PLOT0730
      IF(NODE(I).EQ.0)GO TO 10                                          PLOT0740
C                                                                       PLOT0750
C *** TO MAKE GRID POINT NUMBERS CONNECTED BY ELEMENTS POSITIVE         PLOT0760
      NUMPT(ND) = IABS(NUMPT(ND))                                       PLOT0770
      IF(NUMPT(ND).LT.NDMIN.OR.NUMPT(ND).GT.NDMAX) GO TO 100            PLOT0780
   10 CONTINUE                                                          PLOT0790
      I = KHORZ                                                         PLOT0800
      J = KVERT                                                         PLOT0810
      DO 20 N=1,NEND                                                    PLOT0820
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      IF(NODE(N).EQ.0) GO TO 20                                         PLOT0830
      ND = NODE(N)                                                      PLOT0840
      IF(XPT(ND).GT.XXMAX) GO TO 100                                    PLOT0850
      IF(XPT(ND).LT.XXMIN) GO TO 100                                    PLOT0860
      IF(YPT(ND).GT.YYMAX) GO TO 100                                    PLOT0870
      IF(YPT(ND).LT.YYMIN) GO TO 100                                    PLOT0880
      IF(ZPT(ND).GT.ZZMAX) GO TO 100                                    PLOT0890
      IF(ZPT(ND).LT.ZZMIN) GO TO 100                                    PLOT0900
      XDISP(N) = 0.0                                                    PLOT0910
      YDISP(N) = 0.0                                                    PLOT0920
      ZDISP(N) = 0.0                                                    PLOT0930
      IF(KDISP.EQ.1.AND.NUDISP.NE.0) XDISP(N) = UPT(ND)                 PLOT0940
      IF(KDISP.EQ.1.AND.NVDISP.NE.0) YDISP(N) = VPT(ND)                 PLOT0950
      IF(KDISP.EQ.1.AND.NWDISP.NE.0) ZDISP(N) = WPT(ND)                 PLOT0960
      X(N) = XSIGN*(XPT(ND)+XDISP(N)*DMAG+XSHIFT)/PSCALE                PLOT0970
      Y(N) = YSIGN*(YPT(ND)+YDISP(N)*DMAG+YSHIFT)/PSCALE                PLOT0980
      Z(N) = ZSIGN*(ZPT(ND)+ZDISP(N)*DMAG+ZSHIFT)/PSCALE                PLOT0990
   20 CONTINUE                                                          PLOT1000
      IF(KDISP.EQ.2) CALL XPLOD(NEND,X,Y,Z,NODE)                        PLOT1010
      XCENT = 0.0                                                       PLOT1020
      YCENT = 0.0                                                       PLOT1030
      FND=0.0                                                           PLOT1040
      DO 25 N=1,NEND                                                    PLOT1050
      IF(NODE(N).EQ.0) GO TO 25                                         PLOT1060
      XROT(N) = A(I,1)*X(N)+A(I,2)*Y(N)+A(I,3)*Z(N)                     PLOT1070
      YROT(N) = A(J,1)*X(N)+A(J,2)*Y(N)+A(J,3)*Z(N)                     PLOT1080
      IF(N.GT.8) GO TO 24                                               PLOT1090
      FND=FND+1.0                                                       PLOT1100
      XCENT = XCENT+XROT(N)                                             PLOT1110
      YCENT = YCENT+YROT(N)                                             PLOT1120
   24 CONTINUE                                                          PLOT1130
      XROT(N) = XROT(N)+DELX                                            PLOT1140
      YROT(N) = YROT(N)+DELY                                            PLOT1150
       IF(YROT(N).GT.YPMAX) YPMAX=YROT(N)                               PLOT1160
   25 CONTINUE                                                          PLOT1170
      IF(NOTAT.NE.2) GO TO 29                                           PLOT1180
      XCENT = XCENT/FND-(6.0/7.0)*XLHT                                  PLOT1190
      YCENT = YCENT/FND-XLHT/2.0                                        PLOT1200
      XCENT = XCENT+DELX                                                PLOT1210
      YCENT = YCENT+DELY                                                PLOT1220
      AL = NUMEL                                                        PLOT1230
   29 CONTINUE                                                          PLOT1240
      IF(NOTAT.EQ.2) CALL CALNUM(XCENT,YCENT,XLHT,AL,0.0,-1)            PLOT1250
C                                                                       PLOT1260
C *** TO PLOT ELEMENTS                                                  PLOT1270
C                                                                       PLOT1280
      IF(NEND.EQ.2) GO TO 280                                           PLOT1290
      IF(NEND.EQ.4) GO TO 300                                           PLOT1300
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      IF(NEND.EQ.8) GO TO 320                                           PLOT1310
      IF(NEND.EQ.12) GO TO 340                                          PLOT1320
      IF(NEND.EQ.20) GO TO 340                                          PLOT1330
      CALL ERROR(4)                                                     PLOT1340
C                                                                       PLOT1350
C ***TO PLOT 2 NODE ELEMENT                                             PLOT1360
C                                                                       PLOT1370
  280 CONTINUE                                                          PLOT1380
      CALL CALPLT(XROT(1),YROT(1),3)                                    APR1981
      CALL CALPLT(XROT(2),YROT(2),2)                                    APR1981
      GO TO 430                                                         PLOT1410
C                                                                       PLOT1420
C *** TO PLOT 3 AND 4 NODE PLANE ELEMENT                                PLOT1430
C                                                                       PLOT1440
  300 CONTINUE                                                          PLOT1450
      CALL CALPLT(XROT(1),YROT(1),3)                                    APR1981
      DO 305 NP=2,NEND                                                  PLOT1470
      CALL CALPLT(XROT(NP),YROT(NP),2)                                  APR1981
  305 CONTINUE                                                          PLOT1490
      CALL CALPLT(XROT(1),YROT(1),2)                                    APR1981
      GO TO 430                                                         PLOT1510
C                                                                       PLOT1520
C *** TO PLOT 8 NODE 3-D BRICK                                          PLOT1530
C                                                                       PLOT1540
  320 CONTINUE                                                          PLOT1550
      LP=1                                                              PLOT1560
      DO 330 NP=2,6,4                                                   PLOT1570
         NP2=NP+2                                                       PLOT1580
         CALL CALPLT(XROT(LP),YROT(LP),3)                               APR1981
         DO 325 MP=NP,NP2                                               PLOT1600
            CALL CALPLT(XROT(MP),YROT(MP),2)                            APR1981
  325       CONTINUE                                                    PLOT1620
         CALL CALPLT(XROT(LP),YROT(LP),2)                               APR1981
         LP=LP+4                                                        PLOT1640
  330    CONTINUE                                                       PLOT1650
      DO 335 NP=1,4                                                     PLOT1660
         NP4=NP+4                                                       PLOT1670
         CALL CALPLT(XROT(NP),YROT(NP),3)                               APR1981
         CALL CALPLT(XROT(NP4),YROT(NP4),2)                             APR1981
  335    CONTINUE                                                       PLOT1700
      GO TO 430                                                         PLOT1710
C                                                                       PLOT1720
C *** TO PLOT VARIABLE 4-8 NODE PLANE AND 8-20 NODE BRICK ELEMENTS      PLOT1730
C                                                                       PLOT1740
  340 CONTINUE                                                          PLOT1750
      LP=1                                                              PLOT1760
      KP=8                                                              PLOT1770
      DO 365 NP=2,6,4                                                   PLOT1780
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          NP2=NP+2                                                      PLOT1790
          CALL CALPLT(XROT(LP),YROT(LP),3)                              APR1981
          DO 345 MP=NP,NP2                                              PLOT1810
              KP=KP+1                                                   PLOT1820
              N=2                                                       PLOT1830
              CALL CALWH(XP(1),YP(1))                                   APR1981
              XP(2)=XROT(MP)                                            PLOT1850
              YP(2)=YROT(MP)                                            PLOT1860
              XP(3)=XROT(KP)                                            PLOT1870
              YP(3)=YROT(KP)                                            PLOT1880
              IF(NODE(KP).NE.0) CALL CURVE(XP,YP,N)                     PLOT1890
              CALL CALINE(XP,YP,N)                                      APR1981
  345         CONTINJE                                                  PLOT1910
          KP=KP+1                                                       PLOT1920
         N=2                                                            PLOT1930
         CALL CALWH(XP(1),YP(1))                                        APR1981
         XP(2)=XROT(LP)                                                 PLOT1950
         YP(2)=YROT(LP)                                                 PLOT1960
         XP(3)=XROT(KP)                                                 PLOT1970
         YP(3)=YROT(KP)                                                 PLOT1980
         IF(NODE(KP).NE.0) CALL CURVE(XP,YP,N)                          PLOT1990
         CALL CALINE(XP,YP,N)                                           APR1981
  355     LP=LP+4                                                       PLOT2010
          IF(NEND.EQ.12) GO TO 430                                      PLOT2020
  365     CONTINUE                                                      PLOT2030
      DO 390 NP=1,4                                                     PLOT2040
          NP4=NP+4                                                      PLOT2050
          KP=NP+16                                                      PLOT2060
         N=2                                                            PLOT2070
         XP(1)=XROT(NP)                                                 PLOT2080
         YP(1)=YROT(NP)                                                 PLOT2090
         XP(2)=XROT(NP4)                                                PLOT2100
         YP(2)=YROT(NP4)                                                PLOT2110
         XP(3)=XROT(KP)                                                 PLOT2120
         YP(3)=YROT(KP)                                                 PLOT2130
         IF(NODE(KP).NE.0) CALL CURVE(XP,YP,N)                          PLOT2140
         CALL CALINE(XP,YP,N)                                           APR1981
  390     CONTINUE                                                      PLOT2160
  430 CONTINJE                                                          PLOT2170
      GO TO 100                                                         PLOT2180
 1000 CONTINUE                                                          PLOT2190
      IF(KDISP.NE.3) GO TO 650                                          PLOT2200
  600 CONTINUE                                                          PLOT2210
C                                                                       PLOT2220
C *** TO PLOT VECTORS AT GRID POINTS                                    PLOT2230
C                                                                       PLOT2240
      DO 601 ND=1,NNODE                                                 PLOT2250
      IF(NUMPT(ND).LE.0) GO TO 601                                      PLOT2260
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      IF(NUMPT(ND).LT.NDMIN.OR.NUMPT(ND).GT.NDMAX) GO TO 601            PLOT2270
      IF(XPT(ND).GT.XYZMAX(1)) GO TO 601                                PLOT2280
      IF(XPT(ND).LT.XYZMIN(1)) GO TO 601                                PLOT2290
      IF(YPT(ND).GT.XYZMAX(2)) GO TO 601                                PLOT2300
      IF(YPT(ND).LT.XYZMIN(2)) GO TO 601                                PLOT2310
      IF(ZPT(ND).GT.XYZMAX(3)) GO TO 601                                PLOT2320
      IF(ZPT(ND).LT.XYZMIN(3)) GO TO 601                                PLOT2330
      X(1) = XSIGN*(XPT(ND)+XSHIFT)/PSCALE                              PLOT2340
      Y(1) = YSIGN*(YPT(ND)+YSHIFT)/PSCALE                              PLOT2350
      Z(1) = ZSIGN*(ZPT(ND)+ZSHIFT)/PSCALE                              PLOT2360
      XDISP(1) = 0.0                                                    PLOT2370
      YDISP(1) = 0.0                                                    PLOT2380
      ZDISP(1) = 0.0                                                    PLOT2390
      IF(NUDISP.NE.0) XDISP(1) = UPT(ND)                                PLOT2400
      IF(NVDISP.NE.0) YDISP(1) = VPT(ND)                                PLOT2410
      IF(NWDISP.NE.0) ZDISP(1) = WPT(ND)                                PLOT2420
      X(2) = XSIGN*(XPT(ND)+XDISP(1)*DMAG+XSHIFT)/PSCALE                PLOT2430
      Y(2) = YSIGN*(YPT(ND)+YDISP(1)*DMAG+XSHIFT)/PSCALE                PLOT2440
      Z(2) = ZSIGN*(ZPT(ND)+ZDISP(1)*DMAG+ZSHIFT)/PSCALE                PLOT2450
      I = KHORZ                                                         PLOT2460
      J = KVERT                                                         PLOT2470
      DO 605 N=1,2                                                      PLOT2480
      XROT(N) = A(I,1)*X(N)+A(I,2)*Y(N)+A(I,3)*Z(N)                     PLOT2490
      YROT(N) = A(J,1)*X(N)+A(J,2)*Y(N)+A(J,3)*Z(N)                     PLOT2500
      XROT(N) = XROT(N)+DELX                                            PLOT2510
      YROT(N) = YROT(N)+DELY                                            PLOT2520
  605 CONTINUE                                                          PLOT2530
      XARW = 0.06                                                       PLOT2540
      YARW = XARW/3.0                                                   PLOT2550
      CALL GARROW(XROT(1),YROT(1),XROT(2),YROT(2),1,XARW,YARW)          PLOT2560
  601 CONTINUE                                                          PLOT2570
  650 CONTINUE                                                          PLOT2580
  520 CONTINUE                                                          PLOT2590
  510 CONTINUE                                                          PLOT2600
  500 CONTINUE                                                          PLOT2610
C                                                                       PLOT2620
C *** TO PLOT NODE POINT NUMBERS                                        PLOT2630
C                                                                       PLOT2640
      IF(NOTAT.EQ.1) CALL NDLET(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)          PLOT2650
      CALL CALPLT(-XORGN,-YORGN,-3)                                     APR1981
C                                                                       PLOT2670
C *** TO MAKE ALL GRID POINT NUMBERS POSITIVE AGAIN                     PLOT2680
C                                                                       PLOT2690
      DO 1100 I=1,NNODE                                                 PLOT2700
      NUMPT(I)=IABS(NUMPT(I))                                           PLOT2710
 1100 CONTINUE                                                          PLOT2720
      RETURN                                                            PLOT2730
      END                                                               PLOT2740
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      SUBROUTINE CURVE(XP,YP,N)                                         PLOT2750
C                                                                       PLOT2760
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT2770
C                                                                       PLOT2780
C *** THIS SUBROUTINE INTERPOLATES ALONG THE EDGES OF ISOPARAMETRIC     PLOT2790
C *** ELEMENTS USING SHAPE FUNCTIONS                                    PLOT2800
C *** CALLED BY PLOTX                                                   PLOT2810
C                                                                       PLOT2820
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT2830
C                                                                       PLOT2840
      DIMENSION XP(1),YP(1)                                             PLOT2850
      DIMENSION X(3),Y(3)                                               PLOT2860
      DO 100 I=1,3                                                      PLOT2870
          X(I)=XP(I)                                                    PLOT2880
          Y(I)=YP(I)                                                    PLOT2890
  100     CONTINUE                                                      PLOT2900
      R=-1.0                                                            PLOT2910
      DO 200 I=1,21                                                     PLOT2920
      YP(I)=Y(1)*R*(R-1.0)/2.0-Y(3)*(R+1.0)*(R-1.0)+Y(2)*R*(R+1.0)/2.0  PLOT2930
      XP(I)=X(1)*R*(R-1.0)/2.0-X(3)*(R+1.0)*(R-1.0)+X(2)*R*(R+1.0)/2.0  PLOT2940
          R=R+0.1                                                       PLOT2950
  200     CONTINUE                                                      PLOT2960
      N=21                                                              PLOT2970
      RETURN                                                            PLOT2980
      END                                                               PLOT2990
      SUBROUTINE DSCALE(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                  PLOT3000
C                                                                       PLOT3010
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT3020
C                                                                       PLOT3030
C *** THIS SUBROUTINE DETERMINES THE SCALE FACTOR FOR DISPLACEMENTS     PLOT3040
C *** CALLED BY PSAP1                                                   PLOT3050
C                                                                       PLOT3060
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT3070
C                                                                       PLOT3080
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PLOT3090
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PLOT3100
     2PSCALE,KDISP,DMAG,KODE                                            PLOT3110
      COMMON/SAVEV/ DMAGS,IDMAG                                         PLOT3120
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   PLOT3130
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      PLOT3140
      IF(KDISP.EQ.0.OR.KDISP.EQ.2) GO TO 10                             PLOT3150
      GO TO (10,20), IDMAG                                              PLOT3160
   10 CONTINUE                                                          PLOT3170
      DMAG = DMAGS                                                      PLOT3180
      GO TO 30                                                          PLOT3190
   20 CONTINUE                                                          PLOT3200
      DMAX = 0.0                                                        PLOT3210
      DO 100 I=1,NNODE                                                  PLOT3220
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      IF(NUDISP.EQ.0) GO TO 500                                         PLOT3230
      IF(ABS(UPT(I)).GT.DMAX) DMAX = ABS(UPT(I))                        PLOT3240
  500 CONTINUE                                                          PLOT3250
      IF(NVDISP.EQ.0) GO TO 501                                         PLOT3260
      IF(ABS(VPT(I)).GT.DMAX) DMAX = ABS(VPT(I))                        PLOT3270
  501 CONTINUE                                                          PLOT3280
      IF(NWDISP.EQ.0) GO TO 502                                         PLOT3290
      IF(ABS(WPT(I)).GT.DMAX) DMAX = ABS(WPT(I))                        PLOT3300
  502 CONTINUE                                                          PLOT3310
  100 CONTINUE                                                          PLOT3320
      DMAG = DMAGS/DMAX                                                 PLOT3330
   30 CONTINUE                                                          PLOT3340
      RETURN                                                            PLOT3350
      END                                                               PLOT3360
      SUBROUTINE ROTAT                                                  PLOT3370
C                                                                       PLOT3380
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT3390
C                                                                       PLOT3400
C *** SETS UP COEFFICIENTS OF ROTATION MATRIX                           PLOT3410
C *** CALLED BY PSAP1                                                   PLOT3420
C                                                                       PLOT3430
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT3440
C                                                                       PLOT3450
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PLOT3460
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PLOT3470
     2PSCALE,KDISP,DMAG,KODE                                            PLOT3480
      COMMON/ABLK/ A(3,3)                                               PLOT3490
      PI = 3.1415926536                                                 PLOT3500
      SINPHI = SIN(PHI*PI/180.0)                                        PLOT3510
      COSPHI = COS(PHI*PI/180.0)                                        PLOT3520
      SINTHE = SIN(THETA*PI/180.0)                                      PLOT3530
      COSTHE = COS(THETA*PI/180.0)                                      PLOT3540
      SINPSI = SIN(PSI*PI/180.0)                                        PLOT3550
      COSPSI = COS(PSI*PI/180.0)                                        PLOT3560
      A(1,1) = COSTHE*COSPSI                                            PLOT3570
      A(1,2) = COSPSI*SINTHE*SINPHI-SINPSI*COSPHI                       PLOT3580
      A(1,3) = SINTHE*COSPHI*COSPSI+SINPHI*SINPSI                       PLOT3590
      A(2,1) = SINPSI*COSTHE                                            PLOT3600
      A(2,2) = SINTHE*SINPHI*SINPSI+COSPHI*COSPSI                       PLOT3610
      A(2,3) = SINTHE*COSPHI*SINPSI-SINPHI*COSPSI                       PLOT3620
      A(3,1) = -SINTHE                                                  PLOT3630
      A(3,2) = COSTHE*SINPHI                                            PLOT3640
      A(3,3) = COSTHE*COSPHI                                            PLOT3650
      RETURN                                                            PLOT3660
      END                                                               PLOT3670
      SUBROUTINE XYSCAL                                                 PLOT3680
C                                                                       PLOT3690
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT3700
```

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C *** TO DETERMINE SCALE FACTOR FOR MODEL GEOMETRY.                     PLOT3720
C *** CALLED BY PLOTX                                                   PLOT3730
C                                                                       PLOT3740
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT3750
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PLOT3770
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PLOT3780
     2PSCALE,KDISP,DMAG,KODE                                            PLOT3790
      COMMON/XYZLIM/ XYZMAX(3),XYZMIN(3)                                PLOT3800
      COMMON/CORGN/ YPMAX,YSPACE,PSIZE                                  PLOT3810
      COMMON/ABLK/ A(3,3)                                               PLOT3820
      COMMON/PDELS/ DELX,DELY                                           PLOT3830
      I = KHORZ                                                         PLOT3840
      J = KVERT                                                         PLOT3850
      DMAX = 0.0                                                        PLOT3860
      DO 5 N=1,3                                                        PLOT3870
      VDUM = ABS(XYZMAX(N)-XYZMIN(N))                                   PLOT3880
      IF(VDUM.GT.DMAX) DMAX = VDUM                                      PLOT3890
    5 CONTINUE                                                          PLOT3900
      PSCALE = DMAX/PLOTSZ                                              PLOT3910
      DO 10 L=1,2                                                       PLOT3920
      DO 10 M=1,2                                                       PLOT3930
      DO 10 N=1,2                                                       PLOT3940
      X = XYZMIN(1)                                                     PLOT3950
      IF(L.EQ.2) X = XYZMAX(1)                                          PLOT3960
      Y = XYZMIN(2)                                                     PLOT3970
      IF(M.EQ.2) Y = XYZMAX(2)                                          PLOT3980
      Z = XYZMIN(3)                                                     PLOT3990
      IF(N.EQ.2) Z = XYZMAX(3)                                          PLOT4000
      XROT = A(I,1)*X+A(I,2)*Y+A(I,3)*Z                                 PLOT4010
      YROT = A(J,1)*X+A(J,2)*Y+A(J,3)*Z                                 PLOT4020
      IF(L*M*N.NE.1) GO TO 30                                           PLOT4030
   20 CONTINUE                                                          PLOT4040
      XRMIN = XROT                                                      PLOT4050
      XRMAX = XROT                                                      PLOT4060
      YRMIN = YROT                                                      PLOT4070
      YRMAX = YROT                                                      PLOT4080
   30 CONTINUE                                                          PLOT4090
      IF(XROT.GT.XRMAX) XRMAX = XROT                                    PLOT4100
      IF(XROT.LT.XRMIN) XRMIN = XROT                                    PLOT4110
      IF(YROT.GT.YRMAX) YRMAX = YROT                                    PLOT4120
      IF(YROT.LT.YRMIN) YRMIN = YROT                                    PLOT4130
   10 CONTINUE                                                          PLOT4140
      XR=ABS(XRMAX-XRMIN)                                               PLOT4150
      IF(XR/PSCALE.GT.PSIZE) PSCALE=XR/PSIZE                            PLOT4160
      XRMAX = XRMAX/PSCALE                                              PLOT4170
      YRMAX = YRMAX/PSCALE                                              PLOT4180
      XRMIN = XRMIN/PSCALE                                              PLOT4190
      YRMIN = YRMIN/PSCALE                                              PLOT4200
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      DELX = -XRMIN                                                     PLOT4210
      DELY = -YRMIN                                                     PLOT4220
      XORGN = (PSIZE-XR/PSCALE)/2.0                                     PLOT4230
      YORGN = 0.0                                                       PLOT4240
      RETURN                                                            PLOT4250
      END                                                               PLOT4260
      SUBROUTINE XPLOD(NEND,X,Y,Z,NODE)                                 PLOT4270
C                                                                       PLOT4280
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  PLOT4290
C                                                                       PLOT4300
C *** FOR GENERATING EXPLODED PLOTS.                                    PLOT4310
C *** CALLED BY PLOTX                                                   PLOT4320
C                                                                       PLOT4330
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  PLOT4340
C                                                                       PLOT4350
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PLOT4360
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PLOT4370
     2PSCALE,KDISP,DMAG,KODE                                            PLOT4380
      DIMENSION X(20),Y(20),Z(20),NODE(20)                              PLOT4390
C                                                                       PLOT4400
C *** TO CALCULATE THE INCENTER OF TRIANGLES                            PLOT4410
C                                                                       PLOT4420
      IF(NODE(4).EQ.0) NEND=3                                           PLOT4430
      IF(NEND.NE.3) GO TO 20                                            PLOT4440
   10 CONTINUE                                                          PLOT4450
      A = SQRT((X(2)-X(3))**2+(Y(2)-Y(3))**2+(Z(2)-Z(3))**2)            PLOT4460
      B = SQRT((X(1)-X(3))**2+(Y(1)-Y(3))**2+(Z(1)-Z(3))**2)            PLOT4470
      C = SQRT((X(1)-X(2))**2+(Y(1)-Y(2))**2+(Z(1)-Z(2))**2)            PLOT4480
      AC1 = A/(A+B+C)                                                   PLOT4490
      AC2 = B/(A+B+C)                                                   PLOT4500
      AC3 = C/(A+B+C)                                                   PLOT4510
      XOC = AC1*X(1)+AC2*X(2)+AC3*X(3)                                  PLOT4520
      YOC = AC1*Y(1)+AC2*Y(2)+AC3*Y(3)                                  PLOT4530
      ZOC = AC1*Z(1)+AC2*Z(2)+AC3*Z(3)                                  PLOT4540
      GO TO 190                                                         PLOT4550
   20 CONTINUE                                                          PLOT4560
C                                                                       PLOT4570
C *** TO CALCULATE THE CENTROID OF RODS,BARS,AND QUADS                  PLOT4580
C                                                                       PLOT4590
      XOC = 0.0                                                         PLOT4600
      YOC = 0.0                                                         PLOT4610
      ZOC = 0.0                                                         PLOT4620
      FND=0.0                                                           PLOT4630
      DO 100 I=1,NEND                                                   PLOT4640
      IF(NODE(I).EQ.0) GO TO 100                                        PLOT4650
      IF(I.GT.8) GO TO 101                                              PLOT4660
      FND=FND+1.0                                                       PLOT4670
      XOC = XOC+X(I)                                                    PLOT4680
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      YOC = YOC+Y(I)                                                     PLOT4690
      ZOC = ZOC+Z(I)                                                     PLOT4700
  100 CONTINUE                                                           PLOT4710
  101 CONTINUE                                                           PLOT4720
      XOC=XOC/FND                                                        PLOT4730
      YOC=YOC/FND                                                        PLOT4740
      ZOC=ZOC/FND                                                        PLOT4750
  190 CONTINUE                                                           PLOT4760
C                                                                        PLOT4770
C *** TO REDUCE THE SIZE OF THE ELEMENT                                  PLOT4780
C                                                                        PLOT4790
      DO 200 I=1,NEND                                                    PLOT4800
      IF(NODE(I).EQ.0) GO TO 200                                         PLOT4810
      X(I) = X(I)*DMAG                                                   PLOT4820
      Y(I) = Y(I)*DMAG                                                   PLOT4830
      Z(I) = Z(I)*DMAG                                                   PLOT4840
  200 CONTINUE                                                           PLOT4850
C                                                                        PLOT4860
C *** TO CALCULATE THE CENTROID OF THE REDUCED ELEMENT                   PLOT4870
C                                                                        PLOT4880
      XRC = XOC*DMAG                                                     PLOT4890
      YRC = YOC*DMAG                                                     PLOT4900
      ZRC = ZOC*DMAG                                                     PLOT4910
C                                                                        PLOT4920
C *** SHIFT CORNERS OF ORIGINAL AND REDUCED TO MAKE CENTROIDS MATCH      PLOT4930
C                                                                        PLOT4940
      DO 400 I=1,NEND                                                    PLOT4950
      IF(NODE(I).EQ.0) GO TO 400                                         PLOT4960
      X(I) = X(I)+(XOC-XRC)                                              PLOT4970
      Y(I) = Y(I)+(YOC-YRC)                                              PLOT4980
      Z(I) = Z(I)+(ZOC-ZRC)                                              PLOT4990
  400 CONTINUE                                                           PLOT5000
      RETURN                                                             PLOT5010
      END                                                                PLOT5020
      SUBROUTINE GARROW(X1,Y1,X2,Y2,NC,XHEAD,YHEAD)                      PLOT5030
C                                                                        PLOT5040
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *  PLOT5050
C                                                                        PLOT5060
C *** TO DRAW ARROWS FROM X1,Y1 TO X2,Y2.                                PLOT5070
C *** CALLED BY PLOTX                                                    PLOT5080
C                                                                        PLOT5090
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *  PLOT5100
C                                                                        PLOT5110
      DEN = SQRT((X2-X1)**2+(Y2-Y1)**2)                                  PLOT5120
      IF(DEN.EQ.0.0) GO TO 5000                                          PLOT5130
      C = (X1-X2)/DEN                                                    PLOT5140
      S = (Y1-Y2)/DEN                                                    PLOT5150
      CALL CALPLT(X1,Y1,3)                                               APR1981
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      CALL CALPLT(X2,Y2,2)                                              APR1981
      IF(NC.LT.1) GO TO 1000                                            PLOT5180
      XA = X2+(C*XHEAD-S*YHEAD)                                         PLOT5190
      YA = Y2+(S*XHEAD+C*YHEAD)                                         PLOT5200
      CALL CALPLT(XA,YA,2)                                              APR1981
      IF(NC.LT.2) GO TO 1000                                            PLOT5220
      XB = X2+(C*XHEAD-S*(-YHEAD))                                      PLOT5230
      YB = Y2+(S*XHEAD+C*(-YHEAD))                                      PLOT5240
      CALL CALPLT(XB,YB,2)                                              APR1981
      IF(NC.LT.3) GO TO 1000                                            PLOT5260
      CALL CALPLT(X2,Y2,2)                                              APR1981
      IF(NC.LT.4) GO TO 1000                                            PLOT5280
      XC = X2+(-S*YHEAD)                                                PLOT5290
      YC = Y2+(+C*YHEAD)                                                PLOT5300
      CALL CALPLT(XC,YC,2)                                              APR1981
      IF(NC.LT.5) GO TO 1000                                            PLOT5320
      XD = X2+(-S*(-YHEAD))                                             PLOT5330
      YD = Y2+(+C*(-YHEAD))                                             PLOT5340
      CALL CALPLT(XD,YD,2)                                              APR1981
 1000 CONTINUE                                                          PLOT5360
      CALL CALPLT(X2,Y2,3)                                              APR1981
 5000 CONTINUE                                                          PLOT5380
      RETURN                                                            PLOT5390
      END                                                               PLOT5400
      SUBROUTINE NDLET(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                   PLOT5410
C                                                                       PLOT5420
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT5430
C                                                                       PLOT5440
C *** FOR ANNOTATING GRID POINT NUMBERS ON PLOTS.                       PLOT5450
C *** CALLED BY PSAP1                                                   PLOT5460
C                                                                       PLOT5470
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * PLOT5480
C                                                                       PLOT5490
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, PLOT5500
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        PLOT5510
     2PSCALE,KDISP,DMAG,KODE                                            PLOT5520
      COMMON/LIMITS/ XXMAX,YYMAX,ZZMAX,XXMIN,YYMIN,ZZMIN,NDMAX,NDMIN,   PLOT5530
     1NELMAX,NELMIN                                                     PLOT5540
      COMMON/XYZLIM/ XYZMAX(3),XYZMIN(3)                                PLOT5550
      COMMON/ABLK/ A(3,3)                                               PLOT5560
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   PLOT5570
      COMMON/PDELS/ DELX,DELY                                           PLOT5580
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      PLOT5590
      II = KHORZ                                                        PLOT5600
      JJ = KVERT                                                        PLOT5610
      XSHIFT = 0.0                                                      PLOT5620
      YSHIFT = 0.0                                                      PLOT5630
      ZSHIFT = 0.0                                                      PLOT5640
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      DO 500 I=1,NNODE                                                  PLOT5650
      IF(NUMPT(I).LE.0) GO TO 500                                       PLOT5660
      IF(NUMPT(I).LT.NDMIN.OR.NUMPT(I).GT.NDMAX) GO TO 500              PLOT5670
      IF(XPT(I).GT.XYZMAX(1)) GO TO 500                                 PLOT5680
      IF(XPT(I).LT.XYZMIN(1)) GO TO 500                                 PLOT5690
      IF(YPT(I).GT.XYZMAX(2)) GO TO 500                                 PLOT5700
      IF(YPT(I).LT.XYZMIN(2)) GO TO 500                                 PLOT5710
      IF(ZPT(I).GT.XYZMAX(3)) GO TO 500                                 PLOT5720
      IF(ZPT(I).LT.XYZMIN(3)) GO TO 500                                 PLOT5730
      X = (XPT(I)+XSHIFT)/PSCALE                                        PLOT5740
      Y = (YPT(I)+YSHIFT)/PSCALE                                        PLOT5750
      Z = (ZPT(I)+ZSHIFT)/PSCALE                                        PLOT5760
      XROT = A(II,1)*X+A(II,2)*Y+A(II,3)*Z                              PLOT5770
      YROT = A(JJ,1)*X+A(JJ,2)*Y+A(JJ,3)*Z                              PLOT5780
      XL = XROT+XLHT/2.0                                                PLOT5790
      YL = YROT+XLHT/2.0                                                PLOT5800
      XL = XL+DELX                                                      PLOT5810
      YL = YL+DELY                                                      PLOT5820
      AL = NUMPT(I)                                                     PLOT5830
      CALL CALNUM(XL,YL,XLHT,AL,0.0,-1)                                 APR1981
  500 CONTINUE                                                          PLOT5850
      RETURN                                                            PLOT5860
      END                                                               PLOT5870
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      SUBROUTINE INITAL                                                 INIT0010
C                                                                       INIT0020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT0030
C                                                                       INIT0040
C                                                                       INIT0050
C *** TO SET UP VALJES FOR CONTROL PARAMETERS                           INIT0060
C *** CALLED BY PSAP1                                                   INIT0070
C                                                                       INIT0080
C                                                                       INIT0090
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT0100
C                                                                       INIT0110
      COMMON/CDATA/NTIME,NTLC                                           INIT0120
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, INIT0130
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        INIT0140
     2PSCALE,KDISP,DMAG,KODE                                            INIT0150
      COMMON/LIMITS/ XXMAX,YYMAX,ZZMAX,XXMIN,YYMIN,ZZMIN,NDMAX,NDMIN,   INIT0160
     1NELMAX,NELMIN                                                     INIT0170
      COMMON/CORGN/ YPMAX,YSPACE,PSIZE                                  INIT0180
      COMMON/SAVEV/ DMAGS,IDMAG                                         INIT0190
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   INIT0200
      COMMON/SEQNCE/ IRESEQ                                             INIT0210
      COMMON/VALUES/ NVALUS                                             INIT0220
      COMMON/CASEID/ IDCASE                                             INIT0230
      NAMELIST/OPTION/ NNDEST,NUDISP,NVDISP,NWDISP,                     INIT0240
     1KGEOM,KDATA,NVALUS,IRESEQ,KPLOT,YSPACE,PSIZE,IDCASE               INIT0250
C                                                                       INIT0260
C *** DESCRIPTION OF VALUES IN &OPTION GIVEN IN SUBROUTINE DOCMNT       INIT0270
C                                                                       INIT0280
C                                                                       INIT0290
C *** TO SET DEFAULT VALUES FOR &OPTION                                 INIT0300
C                                                                       INIT0310
      NNDEST = 200                                                      INIT0320
      NUDISP=0                                                          INIT0330
      NVDISP=0                                                          INIT0340
      NWDISP=0                                                          INIT0350
      KGEOM=9                                                           INIT0360
      KDATA=9                                                           INIT0370
      NTIME=0                                                           INIT0380
      NVALUS = 0                                                        INIT0390
      IRESEQ = 1                                                        INIT0400
      KPLOT = 1                                                         INIT0410
      YSPACE=2.0                                                        INIT0420
      PSIZE=9.0                                                         INIT0430
      IDCASE = 0                                                        INIT0440
C                                                                       INIT0450
C *** TO SET DEFAULT VALUES FOR &PICT                                   INIT0460
C                                                                       INIT0470
      KHORZ = 1                                                         INIT0480
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      KVERT = 2                                                         INIT0490
      PHI = 0.0                                                         INIT0500
      THETA = 0.0                                                       INIT0510
      PSI = 0.0                                                         INIT0520
      NEWFR = 1                                                         INIT0530
      ISCALE = 1                                                        INIT0540
      PLOTSZ = 10.0                                                     INIT0550
      XORGN = 0.0                                                       INIT0560
      YORGN = 0.0                                                       INIT0570
      PSCALE = 1.0                                                      INIT0580
      NOTAT = 0                                                         INIT0590
      XLHT = 0.1400                                                     INIT0600
      KDISP = 0                                                         INIT0610
      IDMAG = 2                                                         INIT0620
      DMAGS = 1.0                                                       INIT0630
      KSYMXY = 0                                                        INIT0640
      KSYMXZ = 0                                                        INIT0650
      KSYMYZ = 0                                                        INIT0660
      XXMAX = 1.0E20                                                    INIT0670
      YYMAX = 1.0E20                                                    INIT0680
      ZZMAX = 1.0E20                                                    INIT0690
      XXMIN = -1.0E20                                                   INIT0700
      YYMIN = -1.0E20                                                   INIT0710
      ZZMIN = -1.0E20                                                   INIT0720
      NDMAX = 9999999                                                   INIT0730
      NDMIN = 0                                                         INIT0740
      NELMAX = 9999999                                                  INIT0750
      NELMIN = 0                                                        INIT0760
      KODE = 0                                                          INIT0770
      READ(5,OPTION,END=999)                                            INIT0780
      WRITE(6,9010)                                                     INIT0790
 9010 FORMAT(////)                                                      INIT0800
      WRITE(6,OPTION)                                                   INIT0810
      WRITE(6,9010)                                                     INIT0820
      RETURN                                                            INIT0830
  999 CALL ERROR(3)                                                     INIT0840
      RETURN                                                            INIT0850
      END                                                               INIT0860
      SUBROUTINE BOUND(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                   INIT0870
C                                                                       INIT0880
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT0890
C                                                                       INIT0900
C *** TO DETERMINE MAXIMUM DIMENSIONAL LIMITS OF BODY FOR USE           INIT0910
C     IN SCALING PLOTS                                                  INIT0920
C *** CALLED BY PSAP1                                                   INIT0930
C                                                                       INIT0940
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT0950
C                                                                       INIT0960
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      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT,  INIT0970
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,         INIT0980
     2PSCALE,KDISP,DMAG,KODE                                             INIT0990
      COMMON/LIMITS/ XXMAX,YYMAX,ZZMAX,XXMIN,YYMIN,ZZMIN,NDMAX,NDMIN,    INIT1000
     1NELMAX,NELMIN                                                      INIT1010
      COMMON/XYZLIM/ XYZMAX(3),XYZMIN(3)                                 INIT1020
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                    INIT1030
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)       INIT1040
      DIMENSION NODE(20)                                                 INIT1050
      DO 5 I=1,3                                                         INIT1060
      XYZMIN(I) = +1.0E20                                                INIT1070
      XYZMAX(I) = -1.0E20                                                INIT1080
    5 CONTINUE                                                           INIT1090
      REWIND 10                                                          INIT1100
  100 CONTINUE                                                           INIT1110
      READ(10,END=1000) NEND,NUMEL,(NODE(I),I=1,NEND)                    INIT1120
      IF(NUMEL.LT.NELMIN.OR.NUMEL.GT.NELMAX) GO TO 100                   INIT1130
      DO 10 I=1,NEND                                                     INIT1140
      ND = NODE(I)                                                       INIT1150
      IF(NODE(I).EQ.0) GO TO 10                                          INIT1160
      IF(NUMPT(ND).LT.NDMIN.OR.NUMPT(ND).GT.NDMAX) GO TO 100             INIT1170
   10 CONTINUE                                                           INIT1180
      DO 20 I=1,NEND                                                     INIT1190
      IF(NODE(I).EQ.0) GO TO 20                                          INIT1200
      ND = NODE(I)                                                       INIT1210
      IF(XPT(ND).GT.XXMAX) GO TO 20                                      INIT1220
      IF(XPT(ND).LT.XXMIN) GO TO 20                                      INIT1230
      IF(YPT(ND).GT.YYMAX) GO TO 20                                      INIT1240
      IF(YPT(ND).LT.YYMIN) GO TO 20                                      INIT1250
      IF(ZPT(ND).GT.ZZMAX) GO TO 20                                      INIT1260
      IF(ZPT(ND).LT.ZZMIN) GO TO 20                                      INIT1270
      IF(XPT(ND).GT.XYZMAX(1)) XYZMAX(1) = XPT(ND)                       INIT1280
      IF(XPT(ND).LT.XYZMIN(1)) XYZMIN(1) = XPT(ND)                       INIT1290
      IF(YPT(ND).GT.XYZMAX(2)) XYZMAX(2) = YPT(ND)                       INIT1300
      IF(YPT(ND).LT.XYZMIN(2)) XYZMIN(2) = YPT(ND)                       INIT1310
      IF(ZPT(ND).GT.XYZMAX(3)) XYZMAX(3) = ZPT(ND)                       INIT1320
      IF(ZPT(ND).LT.XYZMIN(3)) XYZMIN(3) = ZPT(ND)                       INIT1330
   20 CONTINUE                                                           INIT1340
      GO TO 100                                                          INIT1350
 1000 CONTINUE                                                           INIT1360
      DO 300 I=1,3                                                       INIT1370
      IF(I.EQ.1.AND.KSYMYZ.NE.1) GO TO 300                               INIT1380
      IF(I.EQ.2.AND.KSYMXZ.NE.1) GO TO 300                               INIT1390
      IF(I.EQ.3.AND.KSYMXY.NE.1) GO TO 300                               INIT1400
      XYZBIG = ABS(XYZMAX(I))                                            INIT1410
      IF(ABS(XYZMIN(I)).GT.XYZBIG) XYZBIG = ABS(XYZMIN(I))               INIT1420
      XYZMAX(I) = XYZBIG                                                 INIT1430
      XYZMIN(I) = -XYZBIG                                                INIT1440
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  300 CONTINUE                                                          INIT1450
      RETURN                                                            INIT1460
      END                                                               INIT1470
      SUBROUTINE ZEROD(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                   INIT1480
C                                                                       INIT1490
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT1500
C                                                                       INIT1510
C *** INITIALIZES ALL DISPLACEMENTS TO ZERO.                            INIT1520
C *** CALLED BY PSAP1                                                   INIT1530
C                                                                       INIT1540
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT1550
C                                                                       INIT1560
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   INIT1570
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      INIT1580
      IF(NUDISP.EQ.0) GO TO 200                                         INIT1590
      DO 150 I=1,NUDISP                                                 INIT1600
      UPT(I) = 0.0                                                      INIT1610
  150 CONTINUE                                                          INIT1620
  200 CONTINUE                                                          INIT1630
      IF(NVDISP.EQ.0) GO TO 300                                         INIT1640
      DO 250 I=1,NVDISP                                                 INIT1650
      VPT(I) = 0.0                                                      INIT1660
  250 CONTINUE                                                          INIT1670
  300 CONTINUE                                                          INIT1680
      IF(NWDISP.EQ.0) GO TO 400                                         INIT1690
      DO 350 I=1,NWDISP                                                 INIT1700
      WPT(I) = 0.0                                                      INIT1710
  350 CONTINUE                                                          INIT1720
  400 CONTINUE                                                          INIT1730
      RETURN                                                            INIT1740
      END                                                               INIT1750
      SUBROUTINE PNTOUT(IOUT,NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)             INIT1760
C                                                                       INIT1770
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT1780
C                                                                       INIT1790
C *** FOR PRINTED OUTPUT OF INFORMATION IN BLANK COMMON - ZZZ           INIT1800
C *** CALLED BY PSAP1                                                   INIT1810
C                                                                       INIT1820
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * INIT1830
C                                                                       INIT1840
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   INIT1850
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      INIT1860
      DIMENSION NODE(20)                                                INIT1870
      GO TO (1000,2000), IOUT                                           INIT1880
 1000 CONTINUE                                                          INIT1890
C                                                                       INIT1900
C *** FOR OUTPUT OF GEOMETRY INFORMATION                                INIT1910
C                                                                       INIT1920
```

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      WRITE(6,16)                                                       INIT1930
   16 FORMAT(///,5X,'GRID POINT INFORMATION',///)                       INIT1940
      WRITE(6,17)                                                       INIT1950
   17 FORMAT(5X,'RESEQUENCED',4X,'USER INPUT'/                          INIT1960
     15X,'GRID POINT',5X,'GRID POINT'/                                  INIT1970
     25X,'NUMBER',9X,'NUMBER',13X,'X',14X,'Y',14X,'Z'//)                INIT1980
      DO 30 I=1,NNODE                                                   INIT1990
      WRITE(6,18) I,NUMPT(I),XPT(I),YPT(I),ZPT(I)                       INIT2000
   18 FORMAT(2X,I10,5X,I10,3X,3E15.4)                                   INIT2010
   30 CONTINUE                                                          INIT2020
      WRITE(6,19)                                                       INIT2030
   19 FORMAT(///,5X,'ELEMENT INFORMATION - WITH RESEQUENCED GRID POINTS INIT2040
     1'///)                                                             INIT2050
      WRITE (6,9008)                                                    INIT2060
 9008 FORMAT(1X,'RESEQUENCED',4X,'USER INPUT',25X,'GRID POINTS'/        INIT2070
     11X,'ELEMENT',8X,'ELEMENT'/                                        INIT2080
     21X,'NUMBER',9X,'NUMBER',7X,'    1    2    3    4    5    6    7   INIT2090
     3 8    9   10   11   12   13   14   15   16   17   18   19   20'//)INIT2100
      REWIND 10                                                         INIT2110
      I = 0                                                             INIT2120
   35 CONTINUE                                                          INIT2130
      I = I+1                                                           INIT2140
      READ(10,END=999) NEND,NUMEL,(NODE(J),J=1,NEND)                    INIT2150
      IF(NEND.EQ.12) GO TO 40                                           INIT2160
      WRITE(6,9010) I,NUMEL,(NODE(J),J=1,NEND)                          INIT2170
 9010 FORMAT(1X,I4,11X,I4,9X,20I5)                                      INIT2180
      GO TO 35                                                          INIT2190
   40 WRITE(6,9010) I,NUMEL,(NODE(J),J=1,4),(NODE(J),J=9,12)            INIT2200
      GO TO 35                                                          INIT2210
 2000 CONTINUE                                                          INIT2220
C                                                                       INIT2230
C *** FOR OUTPUT OF DISPLACEMENT DATA                                   INIT2240
C                                                                       INIT2250
      WRITE(6,210)                                                      INIT2260
  210 FORMAT(///,5X,'DISPLACEMENTS TO BE PLOTTED',///)                  INIT2270
      WRITE(6,17)                                                       INIT2280
      DO 230 I=1,NNODE                                                  INIT2290
      U = 0.0                                                           INIT2300
      IF(NUDISP.NE.0) U = UPT(I)                                        INIT2310
      V = 0.0                                                           INIT2320
      IF(NVDISP.NE.0) V = VPT(I)                                        INIT2330
      W = 0.0                                                           INIT2340
      IF(NWDISP.NE.0) W = WPT(I)                                        INIT2350
      WRITE(6,18) I,NUMPT(I),U,V,W                                      INIT2360
  230 CONTINUE                                                          INIT2370
  999 RETURN                                                            INIT2380
      END                                                               INIT2390
      SUBROUTINE ELTYPE(MTYPE,KGEOM)                                    ELER0010
```

```
C                                                                       ELER0020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ELER0030
C                                                                       ELER0040
C                                                                       ELER0050
C ***THIS SUBROUTINE CALLS OTHER ROUTINES TO READ ELEMENT CONNECTIVITY  ELER0060
C *** MTYPE = ELEMENT TYPE                                              ELER0070
C *** KGEOM = 1    -    ADINA ELEMENTS                                  ELER0080
C *** KGEOM = 2    -    NONSAP ELEMENTS                                 ELER0090
C *** KGEOM = 9    -    SAP IV ELEMENTS                                 ELER0100
C *** CALLED BY GEOM1/GEOM2/GEOM9/                                      ELER0110
C                                                                       ELER0120
C                                                                       ELER0130
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ELER0140
C                                                                       ELER0150
      IF(KGEOM.EQ.1) GO TO 20                                           ELER0160
      IF(KGEOM.EQ.2) GO TO 40                                           ELER0170
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12),MTYPE                          ELER0180
    1 CALL TRUSS                                                        ELER0190
      GO TO 900                                                         ELER0200
    2 CALL BEAM                                                         ELER0210
      GO TO 900                                                         ELER0220
    3 CALL PLANE                                                        ELER0230
      GO TO 900                                                         ELER0240
    4 CALL PLANE                                                        ELER0250
      GO TO 900                                                         ELER0260
    5 CALL THREED                                                       ELER0270
      GO TO 900                                                         ELER0280
    6 CALL SHELL                                                        ELER0290
      GO TO 900                                                         ELER0300
    7 CALL BNDRY                                                        ELER0310
      GO TO 900                                                         ELER0320
    8 CALL SOL21                                                        ELER0330
      GO TO 900                                                         ELER0340
    9 CALL ERROR(1)                                                     ELER0350
      GO TO 900                                                         ELER0360
   10 CALL ERROR(1)                                                     ELER0370
      GO TO 900                                                         ELER0380
   11 CALL ERROR(1)                                                     ELER0390
      GO TO 900                                                         ELER0400
   12 CALL ERROR(1)                                                     ELER0410
      GO TO 900                                                         ELER0420
   20 CONTINUE                                                          ELER0430
      GO TO (21,22,23,24),MTYPE                                         ELER0440
   21 CALL ADTRUS                                                       ELER0450
      GO TO 900                                                         ELER0460
   22 CALL ADPLAN                                                       ELER0470
      GO TO 900                                                         ELER0480
   23 CALL AD3DEE                                                       ELER0490
```

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      GO TO 900                                                         ELER0500
   24 CALL ADBEAM                                                       ELER0510
      GO TO 900                                                         ELER0520
   40 CONTINUE                                                          ELER0530
      GO TO (41,42,43),MTYPE                                            ELER0540
   41 CALL NSTRUS                                                       ELER0550
      GO TO 900                                                         ELER0560
   42 CALL NSPLAN                                                       ELER0570
      GO TO 900                                                         ELER0580
   43 CALL NS3DEE                                                       ELER0590
  900 RETURN                                                            ELER0600
      END                                                               ELER0610
      SUBROUTINE ERROR(N)                                               ELER0620
C                                                                       ELER0630
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ELER0640
C                                                                       ELER0650
C *** THIS SUBROUTINE TERMINATES THE PROGRAM DUE TO ERROR IN INPUT.     ELER0660
C *** ERROR ALSO ZEROS AND ADVANCES THE CALCOMP PLOTTER                 ELER0670
C *** CALLED BY ELTYPE/PSAP1/INITAL/PLOTX/THREED/SOL21/ADTRUS/ADPLAN/   ELER0680
C *** AD3DEE/ADBEAM/NSTRUS/NSPLAN/NS3DEE/GEOM2/                         ELER0690
C                                                                       ELER0700
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ELER0710
C                                                                       ELER0720
      COMMON/CORGN/ YPMAX,YSPACE,PSIZE                                  ELER0730
      CALL CALPLT(0.0,YPMAX+6.0,-3)                                     ELER0740
      GO TO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20),N       ELER0750
    1 CONTINUE                                                          ELER0760
      WRITE(6,9001)                                                     ELER0770
 9001 FORMAT(///,1X,'TERMINATION OCCURRED IN SUBROUTINE ELTYPE   ELEMENTELER0780
     1 IN INPUT DATA CANNOT BE PLOTTED  CHECK ELEMENT TYPES'///)        ELER0790
      GO TO 1000                                                        ELER0800
    2 CONTINUE                                                          ELER0810
      WRITE(6,9002)                                                     ELER0820
 9002 FORMAT(///,1X,'ABNORMAL TERMINATION OCCURRED IN SUBROUTINE PSAP1 CELER0830
     1HECK VALUE OF KODE IN NAMELIST PICT'///)                          ELER0840
      GO TO 1000                                                        ELER0850
    3 CONTINUE                                                          ELER0860
      WRITE(6,9003)                                                     ELER0870
 9003 FORMAT(///,1X,'ABNORMAL TERMINATION OCCURRED IN SUBROUTINE INITAL ELER0880
     1- ATTEMPT TO READ NAMELIST OPTION'///)                            ELER0890
      GO TO 1000                                                        ELER0900
    4 CONTINUE                                                          ELER0910
      WRITE(6,9004)                                                     ELER0920
 9004 FORMAT(//,1X,'ABNORMAL TERMINATION OCCURRED IN PLOTX'//)          ELER0930
      GO TO 1000                                                        ELER0940
    5 CONTINUE                                                          ELER0950
      WRITE(6,9005)                                                     ELER0960
 9005 FORMAT(/,1X,'ABNORMAL TERMINATION IN THREED,ELEMENT CARD ERROR'/) ELER0970
```

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      GO TO 1000                                                        ELER0980
    6 CONTINUE                                                          ELER0990
      WRITE(6,9006)                                                     ELER1000
 9006 FORMAT(/,1X,'ABNORMAL TERMINATION IN SOL21 ,ELEMENT CARD ERROR'/) ELER1010
      GO TO 1000                                                        ELER1020
    7 CONTINUE                                                          ELER1030
      WRITE(6,9007)                                                     ELER1040
 9007 FORMAT(/,1X,'ABNORMAL TERMINATION IN ADTRUS,ELEMENT CARD ERROR'/) ELER1050
      GO TO 1000                                                        ELER1060
    8 CONTINUE                                                          ELER1070
      WRITE(6,9008)                                                     ELER1080
 9008 FORMAT(/,1X,'ABNORMAL TERMINATION IN ADPLAN,ELEMENT CARD ERROR'/) ELER1090
      GO TO 1000                                                        ELER1100
    9 CONTINUE                                                          ELER1110
      WRITE(6,9009)                                                     ELER1120
 9009 FORMAT(/,1X,'ABNORMAL TERMINATION IN AD3DEE,ELEMENT CARD ERROR'/) ELER1130
      GO TO 1000                                                        ELER1140
   10 CONTINUE                                                          ELER1150
      WRITE(6,9010)                                                     ELER1160
 9010 FORMAT(/,1X,'ABNORMAL TERMINATION IN ADBEAM,ELEMENT CARD ERROR'/) ELER1170
      GO TO 1000                                                        ELER1180
   11 CONTINUE                                                          ELER1190
      WRITE(6,9011)                                                     ELER1200
 9011 FORMAT(/,1X,'ABNORMAL TERMINATION IN NSTRUS,ELEMENT CARD ERROR'/) ELER1210
      GO TO 1000                                                        ELER1220
   12 CONTINUE                                                          ELER1230
      WRITE(6,9012)                                                     ELER1240
 9012 FORMAT(/,1X,'ABNORMAL TERMINATION IN NSPLAN,ELEMENT CARD ERROR'/) ELER1250
      GO TO 1000                                                        ELER1260
   13 CONTINUE                                                          ELER1270
      WRITE(6,9013)                                                     ELER1280
 9013 FORMAT(/,1X,'ABNORMAL TERMINATION IN NS3DEE,ELEMENT CARD ERROR'/) ELER1290
      GO TO 1000                                                        ELER1300
   14 CONTINUE                                                          ELER1310
      WRITE(6,9014)                                                     ELER1320
 9014 FORMAT(/,1X,'ABNORMAL TERMINATION NONSAP MESH CANNOT BE PLOTTED'/)ELER1330
      GO TO 1000                                                        ELER1340
   15 CONTINUE                                                          ELER1350
      GO TO 1000                                                        ELER1360
   16 CONTINUE                                                          ELER1370
      GO TO 1000                                                        ELER1380
   17 CONTINUE                                                          ELER1390
      GO TO 1000                                                        ELER1400
   18 CONTINUE                                                          ELER1410
      GO TO 1000                                                        ELER1420
   19 CONTINUE                                                          ELER1430
      GO TO 1000                                                        ELER1440
   20 CONTINUE                                                          ELER1450
```

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 1000 CONTINUE                                                          ELER1460
      CALL PSTOP                                                        ELER1470
      RETURN                                                            ELER1480
      END                                                               ELER1490
      SUBROUTINE GEOM9(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                   SAPF0010
C                                                                       SAPF0020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF0030
C                                                                       SAPF0040
C *** GEOM9 READS SAP IV GEOMETRY DATA                                  SAPF0050
C *** CALLED BY PSAP1                                                   SAPF0060
C                                                                       SAPF0070
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF0080
C                                                                       SAPF0090
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT, SAPF0100
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        SAPF0110
     2PSCALE,KDISP,DMAG,KODE                                            SAPF0120
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   SAPF0130
      COMMON/GCONT/NJMNP,NPAR(20),NELTYP,NUMEL                          SAPF0140
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      SAPF0150
      DATA CTEST/'C    '/                                               SAPF0160
C                                                                       SAPF0170
C *** INSERT ROUTINE HERE                                               SAPF0180
C                                                                       SAPF0190
      READ(5,100) HED                                                   SAPF0200
  100 FORMAT(12A6)                                                      SAPF0210
C                                                                       SAPF0220
C                                                                       SAPF0230
C *** READ MASTER CONTROL CARD                                          SAPF0240
C *** NUMNP = TOTAL NUMBER OF NODE POINTS                               SAPF0250
C *** NELTYP = NUMBER OF ELEMENT GROUPS                                 SAPF0260
C                                                                       SAPF0270
C                                                                       SAPF0280
      READ(5,200)NUMNP,NELTYP                                           SAPF0290
  200 FORMAT(2I5)                                                       SAPF0300
      NNODE=NUMNP                                                       SAPF0310
C                                                                       SAPF0320
C*********READ OR GENERATE NODAL POINT DATA                             SAPF0330
C                                                                       SAPF0340
      NOLD=0                                                            SAPF0350
   10 READ(5,9006) CT,N,XPT(N),YPT(N),ZPT(N),KN                         SAPF0360
 9006 FORMAT(A1,I4,30X,3F10.0,I5)                                       SAPF0370
C                                                                       SAPF0380
C ***CHECK FOR CYLINDRICAL COORDINATES                                  SAPF0390
C                                                                       SAPF0400
      IF(CT.NE.CTEST) GO TO 20                                          SAPF0410
         R=XPT(N)                                                       SAPF0420
         XPT(N)=R*SIN(ZPT(N)/57.2958)                                   SAPF0430
         ZPT(N)=R*COS(ZPT(N)/57.2958)                                   SAPF0440
```

```
   20 CONTINUE                                                          SAPF0450
      NUMPT(N)=N                                                        SAPF0460
      IF (NOLD.EQ.0) GO TO 50                                           SAPF0470
C                                                                       SAPF0480
C*********CHECK IF GENERATION IS REQUIRED                                SAPF0490
C                                                                       SAPF0500
      IF (KN.EQ.0) GO TO 50                                             SAPF0510
      NUM=(N-NOLD)/KN                                                   SAPF0520
      NUMN=NUM-1                                                        SAPF0530
      IF(NUMN.LT.1) GO TO 50                                            SAPF0540
      XNUM=NUM                                                          SAPF0550
      DX=(XPT(N)-XPT(NOLD))/XNUM                                        SAPF0560
      DY=(YPT(N)-YPT(NOLD))/XNUM                                        SAPF0570
      DZ=(ZPT(N)-ZPT(NOLD))/XNUM                                        SAPF0580
      K=NOLD                                                            SAPF0590
      DO 30 J=1,NUMN                                                    SAPF0600
      KK=K                                                              SAPF0610
      K=K+KN                                                            SAPF0620
      XPT(K)=XPT(KK)+DX                                                 SAPF0630
      YPT(K)=YPT(KK)+DY                                                 SAPF0640
      ZPT(K)=ZPT(KK)+DZ                                                 SAPF0650
      NUMPT(K)=K                                                        SAPF0660
   30 CONTINJE                                                          SAPF0670
   50 NOLD=N                                                            SAPF0680
      IF(N.NE.NUMNP) GO TO 10                                           SAPF0690
      NUMEL=0                                                           SAPF0700
C********** READ ELEMENT CONTROL CARDS                                   SAPF0710
      DO 900 M=1,NELTYP                                                 SAPF0720
      READ(5,1001,END=999) (NPAR(I),I=1,14)                             SAPF0730
 1001 FORMAT(14I5)                                                      SAPF0740
      WRITE(6,9010) (NPAR(I),I=1,14)                                    SAPF0750
 9010 FORMAT(///,'  NPAR = ',20I5///)                                   SAPF0760
      MTYPE=NPAR(1)                                                     SAPF0770
      CALL ELTYPE(MTYPE,KGEOM)                                          SAPF0780
  900 CONTINUE                                                          SAPF0790
      ENDFILE 10                                                        SAPF0800
  999 RETURN                                                            SAPF0810
      END                                                               SAPF0820
      SUBROUTINE TRJSS                                                  SAPF0830
C                                                                       SAPF0840
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF0850
C                                                                       SAPF0860
C *** READS SAP IV TRUSS ELEMENT CARDS (ELTYPE 1)                        SAPF0870
C                                                                       SAPF0880
C *** CALLED BY ELTYPE                                                  SAPF0890
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF0900
C                                                                       SAPF0910
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          SAPF0920
```

```
      N2=2                                                              SAPF0930
      NUME=NPAR(2)                                                      SAPF0940
      NUMMAT=NPAR(3)                                                    SAPF0950
C ****  READ MATERIAL PROPERTY CARDS (DUMMY)                             SAPF0960
      DO 10 I=1,NUMMAT                                                  SAPF0970
      READ(5,1001) DUMMY                                                SAPF0980
 1001 FORMAT(10A8)                                                      SAPF0990
   10 CONTINUE                                                          SAPF1000
C ***** READ ELEMENT LOAD MUL. (DUMMY1)                                  SAPF1010
      DO 20 I=1,4                                                       SAPF1020
      READ(5,1001) DUMMY1                                               SAPF1030
   20 CONTINUE                                                          SAPF1040
      IF(NPAR(14).EQ.0) NPAR(14) = 1                                    SAPF1050
      N= NPAR(14)                                                       SAPF1060
C *** READ ELEMENT CONNECTION INFORMATION OR GENERATE                   SAPF1070
  100 READ(5,1004) M,II,JJ,MTYP,TEM,KK                                  SAPF1080
 1004 FORMAT(4I5,F10.0,I5)                                              SAPF1090
      IF(KK.EQ.0) KK=1                                                  SAPF1100
  120 IF (M.NE.N) GO TO 200                                             SAPF1110
      I=II                                                              SAPF1120
      J=JJ                                                              SAPF1130
      KKK=KK                                                            SAPF1140
  200 CONTINUE                                                          SAPF1150
      NUMEL=NUMEL+1                                                     SAPF1160
      WRITE(10) N2,N,I,J                                                SAPF1170
      IF(N.EQ.NUME) RETURN                                              SAPF1180
      N=N+1                                                             SAPF1190
      I=I+KKK                                                           SAPF1200
      J=J+KKK                                                           SAPF1210
      IF(N.GT.M) GO TO 100                                              SAPF1220
      GO TO 120                                                         SAPF1230
      END                                                               SAPF1240
      SUBROUTINE PLANE                                                  SAPF1250
C                                                                       SAPF1260
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF1270
C                                                                       SAPF1280
C *** READS SAP IV MEMBRANE ELEMENT CARDS (ELTYPE 3)                    SAPF1290
C *** CALLED BY ELTYPE                                                  SAPF1300
C                                                                       SAPF1310
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF1320
C                                                                       SAPF1330
      DIMENSION  EMUL(4,5),IE(5),IX(4)                                  SAPF1340
      COMMON/GCONT/NJMNP,NPAR(20),NELTYP,NUMEL                          SAPF1350
      N4=4                                                              SAPF1360
      NUME= NPAR(2)                                                     SAPF1370
      NUMMAT= NPAR(3)                                                   SAPF1380
C ****  READ MATERIAL PROPERTIES                                        SAPF1390
      DO 60 M=1,NUMMAT                                                  SAPF1400
```

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      READ(5,1010) MAT,NT                                               SAPF1410
1010  FORMAT(2I5)                                                       SAPF1420
      IF(NT.EQ.0) NT=1                                                  SAPF1430
      NTC=2* NT                                                         SAPF1440
      DO 50 K=1,NTC                                                     SAPF1450
      READ(5,1005) DUMMY                                                SAPF1460
1005  FORMAT (10A8)                                                     SAPF1470
   50 CONTINUE                                                          SAPF1480
   60 CONTINUE                                                          SAPF1490
C                                                                       SAPF1500
C****  READ ELEMENT LOAD FACTORS                                        SAPF1510
C                                                                       SAPF1520
      READ(5,1002) ((EMUL(I,J),J=1,5),I=1,4)                            SAPF1530
1002  FORMAT(5F10.0)                                                    SAPF1540
C                                                                       SAPF1550
C****  READ ELEMENT PROPERTIES                                          SAPF1560
C                                                                       SAPF1570
      IF(NPAR(14).EQ.0) NPAR(14) = 1                                    SAPF1580
      N=NPAR( 14)-1                                                     SAPF1590
  130 READ(5,1003) M,(IE(I),I=1,4),KG                                   SAPF1600
1003  FORMAT(5I5,30X,I5)                                                SAPF1610
      IF(KG.EQ.0) KG=1                                                  SAPF1620
  140 N=N+1                                                             SAPF1630
      IF(M.EQ.N) GO TO 145                                              SAPF1640
      DO 142 I=1,4                                                      SAPF1650
  142 IX(I)=IX(I)+KG                                                    SAPF1660
      GO TO 150                                                         SAPF1670
  145 DO 148 I=1,4                                                      SAPF1680
  148 IX(I)=IE(I)                                                       SAPF1690
  150 CONTINUE                                                          SAPF1700
      I = IX(1)                                                         SAPF1710
      J = IX(2)                                                         SAPF1720
      K = IX(3)                                                         SAPF1730
      L = IX(4)                                                         SAPF1740
      NUMEL=NUMEL+1                                                     SAPF1750
      WRITE(10) N4,N,I,J,K,L                                            SAPF1760
  310 IF(N.EQ.NUME) RETURN                                              SAPF1770
      IF(N.EQ.M) GO TO 130                                              SAPF1780
      GO TO 140                                                         SAPF1790
      END                                                               SAPF1800
      SUBROUTINE BEAM                                                   SAPF1810
C                                                                       SAPF1820
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF1830
C                                                                       SAPF1840
C *** READS SAP IV BEAM ELEMENT CARDS (ELTYPE 2)                        SAPF1850
C *** CALLED BY ELTYPE                                                  SAPF1860
C                                                                       SAPF1870
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF1880
```

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C                                                                       SAPF1890
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          SAPF1900
      N2=2                                                              SAPF1910
      NUME=NPAR(2)                                                      SAPF1920
      NUMEPC=NPAR(3)                                                    SAPF1930
      NUMFEF=NPAR(4)  * 2                                               SAPF1940
      NUMMAT=NPAR(5)                                                    SAPF1950
C ***  READ MATERIAL PROPERTY CARDS (DUMMY)                             SAPF1960
      DO 10  I=1,NUMMAT                                                 SAPF1970
      READ(5,1001) DUMMY                                                SAPF1980
 1001 FORMAT(10A8)                                                      SAPF1990
   10 CONTINUE                                                          SAPF2000
C ***  READ ELEMENT PROPERTY CARDS (DUMMY1)                             SAPF2010
      DO 20  J=1,NUMEPC                                                 SAPF2020
      READ (5,1001) DUMMY1                                              SAPF2030
   20 CONTINUE                                                          SAPF2040
C ***  READ ELEMENT LOAD MULTIPLIERS(DUMMY2)                             SAPF2050
      DO 30 K=1,3                                                       SAPF2060
      READ (5,1001) DUMMY2                                              SAPF2070
   30 CONTINUE                                                          SAPF2080
C ***  READ  FIXED-END FORCE CARDS(DUMMY3)                              SAPF2090
      DO 40 L=1,NUMFEF                                                  SAPF2100
      READ(5,1001) DUMMY3                                               SAPF2110
   40 CONTINUE                                                          SAPF2120
      IF(NPAR(14).EQ.0) NPAR(14) = 1                                    SAPF2130
      N=NPAR(14)                                                        SAPF2140
C ***  READ ELEMENT CONNECTION  INFO                                    SAPF2150
  100 READ(5,1002) M,II,JJ ,KK                                          SAPF2160
 1002 FORMAT(3I5,47X,I8)                                                SAPF2170
      IF (KK.EQ.0) KK=1                                                 SAPF2180
  120 IF (M.NE.N) GO TO 200                                             SAPF2190
      I = II                                                            SAPF2200
      J = JJ                                                            SAPF2210
      KKK = KK                                                          SAPF2220
  200 CONTINUE                                                          SAPF2230
      NUMEL = NUMEL+1                                                   SAPF2240
      WRITE(10) N2,N,I,J                                                SAPF2250
      IF (N.EQ.NUME) RETURN                                             SAPF2260
      N = N + 1                                                         SAPF2270
      I = I + KKK                                                       SAPF2280
      J = J + KKK                                                       SAPF2290
      IF (N.GT.M) GO TO 100                                             SAPF2300
      GO TO 120                                                         SAPF2310
      END                                                               SAPF2320
      SUBROUTINE THREED                                                 SAPF2330
C                                                                       SAPF2340
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF2350
C                                                                       SAPF2360
```

```
C *** THIS SUBROUTINE READS SAP IV 3-D 8 NODE BRICK ELEMENTS            SAPF2370
C *** CALLED BY ELTYPE                                                  SAPF2380
C                                                                       SAPF2390
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF2400
C                                                                       SAPF2410
      DIMENSION INP(8),NP(8)                                            SAPF2420
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          SAPF2430
      N8=8                                                              SAPF2440
      NUME=NPAR(2)                                                      SAPF2450
      NUMMAT=NPAR(3)                                                    SAPF2460
      NDISLD=NPAR(4)                                                    SAPF2470
C *** READ THE MATERIAL PROPERTIES                                      SAPF2480
      DO 50 M=1,NUMMAT                                                  SAPF2490
          READ(5,9002) DUMMY                                            SAPF2500
 9002 FORMAT(20A4)                                                      SAPF2510
   50     CONTINUE                                                      SAPF2520
C *** READ DISTRIBUTED SURFACE LOADS                                    SAPF2530
      IF(NDISLD.EQ.0) GO TO 61                                          SAPF2540
      DO 60 M=1,NDISLD                                                  SAPF2550
          READ(5,9002) DUMMY                                            SAPF2560
   60     CONTINUE                                                      SAPF2570
   61 CONTINUE                                                          SAPF2580
C *** READ ACCELERATION DUE TO GRAVITY                                  SAPF2590
      READ(5,9002) DUMMY                                                SAPF2600
C *** READ ELEMENT LOAD CASE MULTIPLIERS                                SAPF2610
      DO 80 I=1,5                                                       SAPF2620
          READ(5,9002) DUMMY                                            SAPF2630
   80 CONTINUE                                                          SAPF2640
      IF(NPAR(14).EQ.0) NPAR(14)=1                                      SAPF2650
      NEL=NPAR(14)-1                                                    SAPF2660
  130 READ(5,9006) INEL,(INP(I),I=1,8),ININT,IMAT,IINC                  SAPF2670
 9006 FORMAT(12I5)                                                      SAPF2680
      IF(IINC.EQ.0) IINC=1                                              SAPF2690
  140 NEL=NEL+1                                                         SAPF2700
      ML=INEL-NEL                                                       SAPF2710
      IF(ML)150,155,160                                                 SAPF2720
  150 CALL ERROR(5)                                                     SAPF2730
C *** NO GENERATION OF NODE POINTS REQUIRED                             SAPF2740
  155 DO 156 I=1,8                                                      SAPF2750
          NP(I)=INP(I)                                                  SAPF2760
  156     CONTINUE                                                      SAPF2770
      GO TO 162                                                         SAPF2780
C *** GENERATION REQUIRED                                               SAPF2790
  160 DO 161 I=1,8                                                      SAPF2800
          NP(I)=NP(I)+IINC                                              SAPF2810
  161     CONTINUE                                                      SAPF2820
  162 CONTINUE                                                          SAPF2830
      NUMEL=NUMEL+1                                                     SAPF2840
```

```
      WRITE(10) N8,NEL,(NP(I),I=1,8)                                    SAPF2850
      IF(NEL.EQ.NUME) RETURN                                            SAPF2860
      IF(NEL.EQ.INEL) GO TO 130                                         SAPF2870
      GO TO 140                                                         SAPF2880
      END                                                               SAPF2890
      SUBROUTINE SHELL                                                  SAPF2900
C                                                                       SAPF2910
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF2920
C                                                                       SAPF2930
C *** READS SAP IV SHELL ELEMENT CARDS (ELTYPE 6)                       SAPF2940
C *** CALLED BY ELTYPE                                                  SAPF2950
C                                                                       SAPF2960
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * SAPF2970
C                                                                       SAPF2980
      DIMENSION IY(7),IX(4)                                             SAPF2990
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          SAPF3000
      N4=4                                                              SAPF3010
      ISTOP=0                                                           SAPF3020
      NUME = NPAR(2)                                                    SAPF3030
      NUMMAT = NPAR(3)                                                  SAPF3040
      NMAT= 2*NUMMAT                                                    SAPF3050
C *** READ MATERIAL PROPERTIES (DUMMY)                                  SAPF3060
      DO 10 N=1,NMAT                                                    SAPF3070
      READ(5,1000) DUMMY                                                SAPF3080
C                                                                       SAPF3090
 1000 FORMAT(10A8)                                                      SAPF3100
   10 CONTINUE                                                          SAPF3110
C **** READ ELEMENT LOAD FACTORS (DUMMY1)                               SAPF3120
      DO 20 K=1,5                                                       SAPF3130
      READ(5,1000) DUMMY1                                               SAPF3140
   20 CONTINUE                                                          SAPF3150
      IF(NPAR(14).EQ.0) NPAR(14) = 1                                    SAPF3160
      NN = NPAR(14)-1                                                   SAPF3170
  100 READ(5,1001) MM,IY                                                SAPF3180
 1001 FORMAT(8I5)                                                       SAPF3190
  110 NN = NN + 1                                                       SAPF3200
      IF (MM -NN) 440,50,60                                             SAPF3210
   50 DO 45  I=1,7                                                      SAPF3220
   45 IX(I) = IY(I)                                                     SAPF3230
      INCL = IY(7)                                                      SAPF3240
      IF (INCL.EQ.0)  INCL=1                                            SAPF3250
      GO TO 70                                                          SAPF3260
   60 DO 65  I=1,4                                                      SAPF3270
   65 IX(I)= IX(I) + INCL                                               SAPF3280
   70 CONTINUE                                                          SAPF3290
      I=IX(1)                                                           SAPF3300
      J= IX(2)                                                          SAPF3310
      K=IX(3)                                                           SAPF3320
```

```
      L=IX(4)
      NUMEL = NUMEL +1
      WRITE(10) N4,NN,I,J,K,L
      GO TO 500
  440 WRITE (6,2005) MM
 2005 FORMAT(19HOCARD FOR ELEMT(,I5,14H) IS IN ERROR.,1X)
      ISTOP = 1
  500 IF(NN.LT.MM) GO TO 110
      IF(NN.EQ.NUME) RETURN
      IF(ISTOP.EQ.1) STOP
      GO TO 100
      END
      SUBROUTINE BNDRY
C
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
C
C *** READS SAP IV BOUNDARY ELEMENT CARDS (ELTYPE 7)
C *** BOUNDARY ELEMENTS ARE NOT PLOTTED
C *** CALLED BY ELTYPE
C
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
C
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL
      NUME=NPAR(2)
C *** READ LOAD CASE CARD (DUMMY)
      READ(5,1002) DUMMY
 1002 FORMAT(10A8)
C *** READ BOUNDARY ELEMENT CARDS
      N=0
  100 READ(5,1004) M,II,KK
      N=N+1
      IF(N.GE.NUME) RETURN
      IF(KK.GT.0) GO TO 200
      GO TO 100
  200 READ(5,1004) M2,II2,KK2
      N=N+(M2-M)/KK
      IF(N.GE.NUME) RETURN
      GO TO 100
 1004 FORMAT(2I5,25X,I5)
      END
      SUBROUTINE SOL21
C
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
C
C *** THIS SUBROUTINE READS SAP IV 3-D,8-20 NODE BRICK ELEMENTS
C *** CALLED BY ELTYPE
C
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
```

```
C                                                                       SAPF3810
      DIMENSION NP(20),INP(20)                                          SAPF3820
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          SAPF3830
      N20=20                                                            SAPF3840
      NSOL21=NPAR(2)                                                    SAPF3850
      NUMMAT=NPAR(3)                                                    SAPF3860
      MAXTP=NPAR(4)                                                     SAPF3870
      IF(MAXTP.EQ.0) MAXTP=1                                            SAPF3880
      NORTHO=NPAR(5)                                                    SAPF3890
      NDLS=NPAR(6)                                                      SAPF3900
      MAXNOD=NPAR(7)                                                    SAPF3910
      IF(MAXNOD.EQ.0) MAXNOD=21                                         SAPF3920
      IF(MAXNOD.EQ.8) N20=8                                             SAPF3930
      NOPSET=NPAR(8)                                                    SAPF3940
C *** READ THE MATERIAL PROPERTY CARDS                                  SAPF3950
      DO 50 J=1,NUMMAT                                                  SAPF3960
          READ(5,9002) M,NTP                                            SAPF3970
 9002 FORMAT(2I5)                                                       SAPF3980
          IF(NTP.EQ.0) NTP=1                                            SAPF3990
          NTP2=2*NTP                                                    SAPF4000
          DO 40 JJ=1,NTP2                                               SAPF4010
              READ(5,9004) DUMMY                                        SAPF4020
 9004 FORMAT(20A4)                                                      SAPF4030
   40         CONTINUE                                                  SAPF4040
   50     CONTINUE                                                      SAPF4050
C *** READ MATERIAL AXES ORIENTATION SETS                               SAPF4060
      IF(NORTHO.EQ.0) GO TO 61                                          SAPF4070
      DO 60 J=1,NORTHO                                                  SAPF4080
          READ(5,9004) DUMMY                                            SAPF4090
   60     CONTINUE                                                      SAPF4100
   61 CONTINUE                                                          SAPF4110
C *** READ DISTRIBUTED SURFACE LOAD DATA                                SAPF4120
      IF(NDLS.EQ.0) GO TO 71                                            SAPF4130
      NDLS2=NDLS*2                                                      SAPF4140
      DO 70 J=1,NDLS2                                                   SAPF4150
          READ(5,9004) DUMMY                                            SAPF4160
   70     CONTINUE                                                      SAPF4170
   71 CONTINUE                                                          SAPF4180
C *** READ STRESS OUTPUT LOCATION SETS                                  SAPF4190
      IF(NOPSET.EQ.0) GO TO 81                                          SAPF4200
      DO 80 J=1,NOPSET                                                  SAPF4210
          READ(5,9004) DUMMY                                            SAPF4220
   80     CONTINUE                                                      SAPF4230
   81 CONTINUE                                                          SAPF4240
C *** READ ELEMENT LOAD CASE MULTIPLIERS                                SAPF4250
      DO 90 J=1,5                                                       SAPF4260
          READ(5,9004) DUMMY                                            SAPF4270
   90     CONTINUE                                                      SAPF4280
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C *** READ ELEMENT DATA CARDS                                                   SAPF4290
      IF(NPAR(14).EQ.0) NPAR(14)=1                                              SAPF4300
      NEL=NPAR(14)-1                                                            SAPF4310
  130 READ(5,9006) INEL,IINC                                                    SAPF4320
 9006 FORMAT(I5,35X,I5)                                                         SAPF4330
      READ(5,9008) (INP(I),I=1,N20)                                             SAPF4340
 9008 FORMAT(16I5)                                                              SAPF4350
      IF(IINC.EQ.0) IINC=1                                                      SAPF4360
  140 NEL=NEL+1                                                                 SAPF4370
      ML=INEL-NEL                                                               SAPF4380
      IF(ML) 150,155,160                                                        SAPF4390
  150 CALL ERROR(6)                                                             SAPF4400
C *** NO GENERATION OF NODE POINTS REQUIRED                                     SAPF4410
  155 DO 156 I=1,N20                                                            SAPF4420
         NP(I)=INP(I)                                                           SAPF4430
  156    CONTINUE                                                               SAPF4440
      GO TO 162                                                                 SAPF4450
C *** GENERATION OF NODE POINTS REQUIRED                                        SAPF4460
  160 DO 161 I=1,N20                                                            SAPF4470
         IF(NP(I).EQ.0) GO TO 161                                               SAPF4480
         NP(I)=NP(I)+KN                                                         SAPF4490
  161    CONTINUE                                                               SAPF4500
  162 CONTINUE                                                                  SAPF4510
      NUMEL=NUMEL+1                                                             SAPF4520
      WRITE(10) N20,NEL,(NP(I),I=1,N20)                                         SAPF4530
      IF(NEL.EQ.NSOL21) RETURN                                                  SAPF4540
      IF(NEL.LT.INEL) GO TO 140                                                 SAPF4550
      KN=IINC                                                                   SAPF4560
      GO TO 130                                                                 SAPF4570
      END                                                                       SAPF4580
      SUBROUTINE GEOM1(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)                           ADNA0010
C                                                                               ADNA0020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *     ADNA0030
C                                                                               ADNA0040
C *** THIS ROUTINE READS ADINA DATA CARDS FROM THE TITLE CARD TO THE            ADNA0050
C *** ELEMENT CONTROL CARDS - IT IS CALLED BY PSAP1                             ADNA0060
C                                                                               ADNA0070
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *     ADNA0080
C                                                                               ADNA0090
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT,         ADNA0100
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,                ADNA0110
     2PSCALE,KDISP,DMAG,KODE                                                    ADNA0120
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                           ADNA0130
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                                  ADNA0140
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)              ADNA0150
      DIMENSION IDOF(6),ID(6),IDOLD(6)                                          ADNA0160
     1,NODE(20)                                                                 ADNA0170
      DATA CTEST/'X    '/                                                       ADNA0180
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      NCARD=0                                                           ADNA0190
      READ(5,9000) DUMMY                                                ADNA0200
 9000 FORMAT(20A4)                                                      ADNA0210
C *** READ MASTER CONTROL CARDS                                         ADNA0220
C *** NUMNP = TOTAL NUMBER OF NODE POINTS                               ADNA0230
C *** NELTYP = NUMBER OF ELEMENT GROUPS                                 ADNA0240
      READ(5,9001) NUMNP,(IDOF(I),I=1,6),NEGL,NEGNL,MODEX,NSTE          ADNA0250
 9001 FORMAT(I5,6I1,I4,3I5)                                             ADNA0260
      NELTYP=NEGL+NEGNL                                                 ADNA0270
      NNODE=NUMNP                                                       ADNA0280
      READ(5,9002) IMASS,IDAMP,IMASSN,IDAMPN                            ADNA0290
 9002 FORMAT(4I5)                                                       ADNA0300
      READ(5,9002) IEIG                                                 ADNA0310
      READ(5,9002) ISREF,NUMREF,IEQUIT,ITEMAX                           ADNA0320
      READ(5,9000) DUMMY                                                ADNA0330
      READ(5,9000) DUMMY                                                ADNA0340
      READ(5,9000) DUMMY                                                ADNA0350
C *** READ OR GENERATE NODAL POINT DATA                                 ADNA0360
      NOLD=0                                                            ADNA0370
      NEQ=0                                                             ADNA0380
   10 READ(5,9006)CT,N,(ID(I),I=1,6),XPT(N),YPT(N),ZPT(N),KN            ADNA0390
 9006 FORMAT(A1,I4,1X,I4,5I5,3F10.0,I5)                                 ADNA0400
C *** CHECK FOR CYLINDRICAL COORDINATES                                 ADNA0410
      IF(CT.NE.CTEST) GO TO 12                                          ADNA0420
         DUM=ZPT(N)/57.2958                                             ADNA0430
         R=YPT(N)                                                       ADNA0440
         YPT(N)=R*COS(ZPT(N)/57.2958)                                   ADNA0450
         ZPT(N)=R*SIN(ZPT(N)/57.2958)                                   ADNA0460
   12 CONTINUE                                                          ADNA0470
      NUMPT(N)=N                                                        ADNA0480
      IF(NOLD.EQ.0) GO TO 50                                            ADNA0490
C *** FOR GENERATION OF FIXED BOUNDARY CONDITIONS                       ADNA0500
      DO 15 I=1,6                                                       ADNA0510
      IF(IDOLD(I).EQ.-1.AND.ID(I).EQ.0) ID(I)=IDOLD(I)                  ADNA0520
   15    CONTINUE                                                       ADNA0530
      IF(KNOLD.EQ.0) GO TO 50                                           ADNA0540
      NUM=(N-NOLD)/KNOLD                                                ADNA0550
      NUMN=NUM-1                                                        ADNA0560
      IF(NUMN.LT.1) GO TO 50                                            ADNA0570
C *** TO COUNT DOFS TO DETERMINE NUMBER OF IC CARDS                     ADNA0580
      DO 20 I=1,6                                                       ADNA0590
         IF(IDOF(I).EQ.0.AND.IDOLD(I).EQ.0) NEQ=NEQ+NUMN                ADNA0600
   20 CONTINUE                                                          ADNA0610
      DX=(XPT(N)-XPT(NOLD))/NUM                                         ADNA0620
      IF(CT.NE.CTEST) GO TO 21                                          ADNA0630
      ROLD=YPT(NOLD)/COS(DUMOLD)                                        ADNA0640
      RNEW=YPT(N)/COS(DUM)                                              ADNA0650
      DR=(RNEW-ROLD)/NUM                                                ADNA0660
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      DT=(DUM-DUMOLD)/NUM                                               ADNA0670
      GO TO 22                                                          ADNA0680
   21 CONTINUE                                                          ADNA0690
      DY=(YPT(N)-YPT(NOLD))/NUM                                         ADNA0700
      DZ=(ZPT(N)-ZPT(NOLD))/NUM                                         ADNA0710
   22 CONTINUE                                                          ADNA0720
      K=NOLD                                                            ADNA0730
      DO 30 J=1,NUMN                                                    ADNA0740
         KK=K                                                           ADNA0750
         K=K+KNOLD                                                      ADNA0760
         XPT(K)=XPT(KK)+DX                                              ADNA0770
          IF(CT.NE.CTEST) GO TO 26                                      ADNA0780
          ROLD=ROLD+DR                                                  ADNA0790
          DUMOLD=DUMOLD+DT                                              ADNA0800
          YPT(K)=ROLD*COS(DUMOLD)                                       ADNA0810
          ZPT(K)=ROLD*SIN(DUMOLD)                                       ADNA0820
          GO TO 28                                                      ADNA0830
   26     CONTINUE                                                      ADNA0840
         YPT(K)=YPT(KK)+DY                                              ADNA0850
         ZPT(K)=ZPT(KK)+DZ                                              ADNA0860
   28     CONTINUE                                                      ADNA0870
         NUMPT(K)=K                                                     ADNA0880
   30    CONTINUE                                                       ADNA0890
   50 NOLD=N                                                            ADNA0900
      KNOLD=KN                                                          ADNA0910
      DUMOLD=DUM                                                        ADNA0920
C *** TO COUNT DOFS TO DETERMINE NUMBER OF IC CARDS                      ADNA0930
      DO 55 I=1,6                                                       ADNA0940
          IF(IDOF(I).EQ.0.AND.ID(I).EQ.0) NEQ=NEQ+1                     ADNA0950
          IDOLD(I)=ID(I)                                                ADNA0960
   55    CONTINUE                                                       ADNA0970
      IF(N.NE.NUMNP) GO TO 10                                           ADNA0980
C *** READ LOAD CONTROL CARDS                                           ADNA0990
      READ(5,9000) DUMMY                                                ADNA1000
      DO 80 I=1,IMASSN                                                  ADNA1010
      IF(IMASSN.EQ.0) GO TO 81                                          ADNA1020
         READ(5,9000) DUMMY                                             ADNA1030
   80    CONTINUE                                                       ADNA1040
   81 CONTINUE                                                          ADNA1050
      IF(IDAMPN.EQ.0) GO TO 91                                          ADNA1060
      DO 90 I=1,IDAMPN                                                  ADNA1070
         READ(5,9000) DUMMY                                             ADNA1080
   90    CONTINUE                                                       ADNA1090
   91 CONTINUE                                                          ADNA1100
C *** READ INITIAL CONDITIONS                                           ADNA1110
      READ(5,9002) ICON                                                 ADNA1120
      IF(ICON.EQ.0) GO TO 100                                           ADNA1130
      CARDNR=NEQ/6.0                                                    ADNA1140
```

```
      NCARD=INT(CARDNR)                                                 ADNA1150
      TEST=CARDNR-NCARD                                                 ADNA1160
      IF(TEST.GT.0.1) NCARD=NCARD+1                                     ADNA1170
      DO 95 I=1,NCARD                                                   ADNA1180
         READ(5,9000) DUMMY                                             ADNA1190
   95    CONTINUE                                                       ADNA1200
      IF(IMASS.EQ.0) GO TO 100                                          ADNA1210
      DO 96 I=1,NCARD                                                   ADNA1220
         READ(5,9000) DUMMY                                             ADNA1230
   96    CONTINUE                                                       ADNA1240
      DO 98 I=1,NCARD                                                   ADNA1250
         READ(5,9000) DUMMY                                             ADNA1260
   98    CONTINUE                                                       ADNA1270
 9007 FORMAT(6E12.6)                                                    ADNA1280
  100 CONTINUE                                                          ADNA1290
      NUMEL=0                                                           ADNA1300
      WRITE(6,9009) NEQ,NCARD                                           ADNA1310
 9009 FORMAT(///,' NEQ AND NCARD FOR IC IN GEOM1  = ',I5,10X,I5///)     ADNA1320
C *** READ ELEMENT CONTROL CARDS                                         ADNA1330
      DO 900 M=1,NELTYP                                                 ADNA1340
         READ(5,9008,END=999)(NPAR(I),I=1,20)                           ADNA1350
      WRITE(6,9010) (NPAR(I),I=1,20)                                    ADNA1360
 9008 FORMAT(20I4)                                                      ADNA1370
 9010 FORMAT(///,'  NPAR = ',20I5///)                                   ADNA1380
         MTYPE=NPAR(1)                                                  ADNA1390
         CALL ELTYPE(MTYPE,KGEOM)                                       ADNA1400
  900    CONTINUE                                                       ADNA1410
      ENDFILE 10                                                        ADNA1420
  999 RETURN                                                            ADNA1430
      END                                                               ADNA1440
      SUBROUTINE ADTRUS                                                 ADNA1450
C                                                                       ADNA1460
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA1470
C                                                                       ADNA1480
C *** THIS SUBROUTINE TO READ ADINA TRUSS DATA                          ADNA1490
C *** THIS ROUTINE CALLED BY ELTYPE                                     ADNA1500
C                                                                       ADNA1510
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA1520
C                                                                       ADNA1530
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          ADNA1540
      NUMMAT=NPAR(16)                                                   ADNA1550
      N2=2                                                              ADNA1560
      IF(NUMMAT.EQ.0) NUMMAT=1                                          ADNA1570
      IF(NPAR(15).EQ.1) NCARD=2                                         ADNA1580
      IF(NPAR(15).EQ.3) NCARD=3                                         ADNA1590
      IF(NPAR(15).NE.2) GO TO 20                                        ADNA1600
      CARDNR=NPAR(17)/8.0                                               ADNA1610
      NCARD=INT(CARDNR)                                                 ADNA1620
```

```
      TEST=CARDNR-NCARD                                                 ADNA1630
      IF(TEST.GT.0.1) NCARD=NCARD+1                                     ADNA1640
      NCARD=VCARD+2                                                     ADNA1650
   20 CONTINJE                                                          ADNA1660
C *** READ MATERIAL PROPERTIES                                           ADNA1670
      DO 50 J=1,NUMMAT                                                  ADNA1680
          DO 45 I=1,NCARD                                               ADNA1690
              READ(5,9000) DUMMY                                        ADNA1700
 9000 FORMAT(20A4)                                                      ADNA1710
   45         CONTINJE                                                  ADNA1720
   50     CONTINUE                                                      ADNA1730
C *** READ OR GENERATE ELEMENT DATA CARDS                               ADNA1740
      IF(NPAR(14).EQ.0) NPAR(14)=1                                      ADNA1750
      NEL=NPAR(14)-1                                                    ADNA1760
  130 READ(5,9002) IVEL,II,JJ,IINC                                      ADNA1770
 9002 FORMAT(3I5,20X,I5)                                                ADNA1780
      IF(IINC.EQ.0) IINC=1                                              ADNA1790
  140 NEL=NEL+1                                                         ADNA1800
      ML=INEL-NEL                                                       ADNA1810
      IF(ML) 150,155,160                                                ADNA1820
  150 CALL ERROR(7)                                                     ADNA1830
C *** NO GENERATION OF NODE POINTS REQUIRED                             ADNA1840
  155 I=II                                                              ADNA1850
      J=JJ                                                              ADNA1860
      GO TO 162                                                         ADNA1870
C *** GENERATION OF VODE POINTS REQUIRED                                ADNA1880
  160 I=I+KN                                                            ADNA1890
      J=J+KN                                                            ADNA1900
  162 CONTINUE                                                          ADNA1910
      NUMEL=NUMEL+1                                                     ADNA1920
      WRITE(10) N2,VEL,I,J                                              ADNA1930
      IF(NEL.EQ.NPAR(2)) RETURN                                         ADNA1940
      IF(NEL.LT.INEL) GO TO 140                                         ADNA1950
      KN=IINC                                                           ADNA1960
      GO TO 130                                                         ADNA1970
      END                                                               ADNA1980
      SUBROUTINE ADPLAN                                                 ADNA1990
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          ADNA2000
      DIMENSION NP(12),INP(8)                                           ADNA2010
C                                                                       ADNA2020
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA2030
C                                                                       ADNA2040
C *** THIS SUBROUTINE TO READ ADINA 8-NODE PLANE ELEMENT DATA           ADNA2050
C *** IT IS CALLED BY ELTYPE                                            ADNA2060
C                                                                       ADNA2070
C                                                                       ADNA2080
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA2090
C                                                                       ADNA2100
```

```
      NUMMAT=NPAR(16)                                                   ADNA2110
      NSTRES=NPAR(13)                                                   ADNA2120
C *** CALCULATE THE NUMBER OF MATERIAL CASE CARDS                        ADNA2130
      IF(NPAR(15).EQ. 1) NCARD=1                                        ADNA2140
      IF(NPAR(15).EQ. 2) NCARD=1                                        ADNA2150
      IF(NPAR(15).EQ. 3) NCARD=4                                        ADNA2160
      IF(NPAR(15).EQ. 4) NCARD=4                                        ADNA2170
      IF(NPAR(15).EQ. 5) NCARD=2                                        ADNA2180
      IF(NPAR(15).EQ. 7) NCARD=1                                        ADNA2190
      IF(NPAR(15).EQ. 8) NCARD=1                                        ADNA2200
      IF(NPAR(15).EQ. 9) NCARD=1                                        ADNA2210
      IF(NPAR(15).EQ.10) NCARD=6                                        ADNA2220
      IF(NPAR(15).EQ.11) NCARD=6                                        ADNA2230
      IF(NPAR(15).EQ.13) NCARD=1                                        ADNA2240
      IF(NPAR(15).NE.14)  GO TO 20                                      ADNA2250
      CARDNR=NPAR(17)/8.0                                               ADNA2260
      NCARD=INT(CARDNR)                                                 ADNA2270
      TEST=CARDNR-NCARD                                                 ADNA2280
      IF(TEST.GT.0.1) NCARD=NCARD+1                                     ADNA2290
   20 CONTINUE                                                          ADNA2300
      N12=12                                                            ADNA2310
C *** READ MATERIAL PROPERTIES                                          ADNA2320
      DO 50 J=1,NUMMAT                                                  ADNA2330
          READ(5,9000) DUMMY                                            ADNA2340
 9000 FORMAT(20A4)                                                      ADNA2350
          DO 45 I=1,NCARD                                               ADNA2360
              READ(5,9000) DUMMY                                        ADNA2370
   45              CONTINUE                                             ADNA2380
   50     CONTINUE                                                      ADNA2390
C *** READ STRESS OUTPUT TABLE CARDS                                    ADNA2400
      IF(NPAR(13).EQ.0) GO TO 61                                        ADNA2410
      DO 60 I=1,NSTRES                                                  ADNA2420
          READ(5,9000)DUMMY                                             ADNA2430
   60     CONTINUE                                                      ADNA2440
   61 CONTINUE                                                          ADNA2450
C *** READ AND GENERATE ELEMENT DATA CARDS                              ADNA2460
      IF(NPAR(14).EQ.0) NPAR(14)=1                                      ADNA2470
      NEL=NPAR(14)-1                                                    ADNA2480
  130 READ(5,9002) INEL,IINC                                            ADNA2490
      IF(IINC.EQ.0) IINC=1                                              ADNA2500
 9002 FORMAT(I5,15X,I5)                                                 ADNA2510
      READ(5,9004)(INP(I),I=1,8)                                        ADNA2520
 9004 FORMAT(8I5)                                                       ADNA2530
  140 NEL=NEL+1                                                         ADNA2540
      ML=INEL-NEL                                                       ADNA2550
      IF(ML)150,155,160                                                 ADNA2560
  150 CALL ERROR(8)                                                     ADNA2570
C *** NO GENERATION OF NODE POINTS REQUIRED                             ADNA2580
```

```
  155 DO 156 I=1,4                                                      ADNA2590
           I5=I+4                                                       ADNA2600
           I9=I+8                                                       ADNA2610
           NP(I)=INP(I)                                                 ADNA2620
           NP(I5)=0                                                     ADNA2630
           NP(I9)=INP(I5)                                               ADNA2640
  156      CONTINUE                                                     ADNA2650
      GO TO 162                                                         ADNA2660
C *** GENERATION OF NODE POINTS REQUIRED                                 ADNA2670
  160 DO 161 I=1,N12                                                    ADNA2680
           IF(NP(I).EQ.0) GO TO 161                                     ADNA2690
           NP(I)=NP(I)+KN                                               ADNA2700
  161      CONTINUE                                                     ADNA2710
  162 CONTINUE                                                          ADNA2720
      NUMEL=NUMEL+1                                                     ADNA2730
      WRITE(10) N12,NEL,(NP(I),I=1,N12)                                 ADNA2740
      IF(NEL.EQ.NPAR(2)) RETURN                                         ADNA2750
      IF(NEL.LT.INEL) GO TO 140                                         ADNA2760
      KN=IINC                                                           ADNA2770
      GO TO 130                                                         ADNA2780
      END                                                               ADNA2790
      SUBROUTINE AD3DEE                                                 ADNA2800
C                                                                       ADNA2810
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA2820
C                                                                       ADNA2830
C *** THIS SUBROUTINE TO READ ADINA 3-D SOLID ELEMENT DATA              ADNA2840
C *** THIS ROUTINE CALLED BY ELTYPE                                     ADNA2850
C                                                                       ADNA2860
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA2870
C                                                                       ADNA2880
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          ADNA2890
      DIMENSION NP(20),INP(20)                                          ADNA2900
      NUMMAT=NPAR(16)                                                   ADNA2910
      NSTRES=NPAR(13)                                                   ADNA2920
C *** CALCULATE THE NUMBER OF MATERIAL CASE CARDS                       ADNA2930
      IF(NPAR(15).EQ. 1) NCARD=1                                        ADNA2940
      IF(NPAR(15).EQ. 2) NCARD=2+NPAR(18)                               ADNA2950
      IF(NPAR(15).EQ. 3) NCARD=4                                        ADNA2960
      IF(NPAR(15).EQ. 4) NCARD=4                                        ADNA2970
      IF(NPAR(15).EQ. 5) NCARD=2                                        ADNA2980
      IF(NPAR(15).EQ. 8) NCARD=1                                        ADNA2990
      IF(NPAR(15).EQ. 9) NCARD=1                                        ADNA3000
      IF(NPAR(15).EQ.10) NCARD=6                                        ADNA3010
      IF(NPAR(15).EQ.11) NCARD=6                                        ADNA3020
      IF(NPAR(15).NE.12) GO TO 20                                       ADNA3030
      CARDNR=NPAR(17)/8.0                                               ADNA3040
      NCARD=INT(CARDNR)                                                 ADNA3050
      TEST=CARDNR-NCARD                                                 ADNA3060
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      IF(TEST.GT.0.1) NCARD=NCARD+1                                     ADNA3070
   20 CONTINJE                                                          ADNA3080
      N20=20                                                            ADNA3090
C *** READ MATERIAL PROPERTIES                                          ADNA3100
      DO 50 J=1,NUMMAT                                                  ADNA3110
         READ(5,9000) DUMMY                                             ADNA3120
 9000 FORMAT(20A4)                                                      ADNA3130
         DO 45 I=1,NCARD                                                ADNA3140
            READ(5,9000) DUMMY                                          ADNA3150
   45       CONTINJE                                                    ADNA3160
   50    CONTINUE                                                       ADNA3170
C *** READ STRESS OUTPUT TABLE CARDS                                    ADNA3180
      IF(NPAR(13).EQ.0) GO TO 61                                        ADNA3190
      DO 60 I=1,NSTRES                                                  ADNA3200
         READ(5,9000) DUMMY                                             ADNA3210
   60    CONTINUE                                                       ADNA3220
   61 CONTINUE                                                          ADNA3230
      IF(NPAR(14).EQ.0) NPAR(14)=1                                      ADNA3240
      NEL=NPAR(14)-1                                                    ADNA3250
  130 READ(5,9002) INEL,IINC                                            ADNA3260
 9002 FORMAT(I5,30X,I5)                                                 ADNA3270
      IF(IINC.EQ.0) IINC=1                                              ADNA3280
      READ(5,9004) (INP(I),I=1,8)                                       ADNA3290
      READ(5,9004) (INP(I),I=9,N20)                                     ADNA3300
 9004 FORMAT(12I5)                                                      ADNA3310
  140 NEL=NEL+1                                                         ADNA3320
      ML=INEL-NEL                                                       ADNA3330
      IF(ML) 150,155,160                                                ADNA3340
  150 CALL ERROR(9)                                                     ADNA3350
C *** NO GENERATION OF NODE POINTS REQUIRED                             ADNA3360
  155 DO 156 I=1,N20                                                    ADNA3370
         NP(I)=INP(I)                                                   ADNA3380
  156    CONTINUE                                                       ADNA3390
      GO TO 162                                                         ADNA3400
C *** GENERATION OF NODE POINTS REQUIRED                                ADNA3410
  160 DO 161 I=1,N20                                                    ADNA3420
         IF(NP(I).EQ.0) GO TO 161                                       ADNA3430
         NP(I)=NP(I)+KN                                                 ADNA3440
  161    CONTINUE                                                       ADNA3450
  162 CONTINUE                                                          ADNA3460
      NUMEL=NUMEL+1                                                     ADNA3470
      WRITE(10) N20,NEL,(NP(I),I=1,N20)                                 ADNA3480
      IF(NEL.EQ.NPAR(2)) RETURN                                         ADNA3490
      IF(NEL.LT.INEL) GO TO 140                                         ADNA3500
      KN=IINC                                                           ADNA3510
      GO TO 130                                                         ADNA3520
      END                                                               ADNA3530
      SUBROUTINE ADBEAM                                                 ADNA3540
```

```
C                                                                       ADNA3550
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA3560
C                                                                       ADNA3570
C *** THIS SUBROUTINE TO READ ADINA 2NODE BEAM ELEMENTS                  ADNA3580
C *** THIS ROUTINE CALLED BY ELTYPE                                     ADNA3590
C                                                                       ADNA3600
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * ADNA3610
C                                                                       ADNA3620
      COMMON/GCONT/NUMNP,NPAR(20),NELTYP,NUMEL                          ADNA3630
      N2=2                                                              ADNA3640
      NUMMAT=NPAR(15)                                                   ADNA3650
      IF(NUMMAT.EQ.0) NUMMAT=1                                          ADNA3660
C *** READ MATERIAL PROPERTIES                                          ADNA3670
      DO 50 J=1,NUMMAT                                                  ADNA3680
          DO 45 I=1,2                                                   ADNA3690
              READ(5,9000) DUMMY                                        ADNA3700
 9000 FORMAT(20A4)                                                      ADNA3710
   45         CONTINUE                                                  ADNA3720
   50     CONTINUE                                                      ADNA3730
C *** READ STRESS OUTPUT TABLE CARDS                                    ADNA3740
      IF(NPAR(13).EQ.0) GO TO 81                                        ADNA3750
      IF(NPAR(14).EQ.0) NPAR(14)=16                                     ADNA3760
      NST=NPAR(13)                                                      ADNA3770
      CARDST=NPAR(14)/16.0                                              ADNA3780
      NCDST=INT(CARDST)                                                 ADNA3790
      TEST=CARDST-NCDST                                                 ADNA3800
      IF(TEST.GT.0.01) NCDST=NCDST+1                                    ADNA3810
      NST=NST*NCDST                                                     ADNA3820
      DO 80 I=1,NST                                                     ADNA3830
          READ(5,9000) DUMMY                                            ADNA3840
   80     CONTINUE                                                      ADNA3850
   81 CONTINUE                                                          ADNA3860
C *** READ OR GENERATE ELEMENT DATA CARDS                               ADNA3870
      IF(NPAR(17).EQ.0) NPAR(17)=1                                      ADNA3880
      NEL=NPAR(17)-1                                                    ADNA3890
  130 READ(5,9002) INEL,II,JJ,IINC                                      ADNA3900
 9002 FORMAT(3I5,15X,I5)                                                ADNA3910
      IF(IINC.EQ.0) IINC=1                                              ADNA3920
  140 NEL=NEL+1                                                         ADNA3930
      ML=INEL-NEL                                                       ADNA3940
      IF(ML) 150,155,160                                                ADNA3950
  150 CALL ERROR(10)                                                    ADNA3960
C *** NO GENERATION OF NODE POINTS REQUIRED                             ADNA3970
  155 I=II                                                              ADNA3980
      J=JJ                                                              ADNA3990
      GO TO 162                                                         ADNA4000
C *** GENERATION OF NODE POINTS REQUIRED                                ADNA4010
  160 I=I+KN                                                            ADNA4020
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      J=J+KN                                                            ADNA4030
  162 CONTINUE                                                          ADNA4040
      NUMEL=NUMEL+1                                                     ADNA4050
      WRITE(10) N2,NEL,I,J                                              ADNA4060
      IF(NEL.EQ.NPAR(2)) RETURN                                         ADNA4070
      IF(NEL.LT.INEL) GO TO 140                                         ADNA4080
      KN=IINC                                                           ADNA4090
      GO TO 130                                                         ADNA4100
      END                                                               ADNA4110
```

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C ******* SUBROUTINES NFRAME AND CCRT2 DELETED **********          APR1981
      SUBROUTINE GEOM2(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)               AUXL0080
C                                                                   APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *APR1981
C                                                                   APR1981
C********* USER SUP>LIED SUBROUTINE SPACE ************              APR1981
C                                                                   APR1981
CC *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *APR1981
      CALL ERROR(14)                                                AUXL0090
      RETURN                                                        AUXL0100
      END                                                           AUXL0110
      SUBROUTINE NSTRUS                                             AUXL0120
C                                                                   AUXL0130
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * AUXL0140
C                                                                   AUXL0150
C *** THIS SUBROUTINE TO READ NON SAP TRUSS ELEMENTS                AUXL0160
C *** CALLED BY ELTYPE                                              AUXL0170
C                                                                   AUXL0180
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * AUXL0190
C                                                                   AUXL0200
      RETURN                                                        AUXL0210
      END                                                           AUXL0220
      SUBROUTINE NSPLAN                                             AUXL0230
C                                                                   AUXL0240
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * AUXL0250
C                                                                   AUXL0260
C *** THIS SUBROUTINE TO READ NON SAP 2 D 8 NODE PLANE ELEMENTS     AUXL0270
C *** CALLED BY ELTYPE                                              AUXL0280
C                                                                   AUXL0290
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * AUXL0300
C                                                                   AUXL0310
      RETURN                                                        AUXL0320
      END                                                           AUXL0330
      SUBROUTINE NS3DEE                                             AUXL0340
C                                                                   AUXL0350
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * AUXL0360
C                                                                   AUXL0370
C *** THIS SUBROUTINE TO READ NON SAP 3-D ELEMENT DATA              AUXL0380
C *** CALLED BY ELTYPE                                              AUXL0390
C                                                                   AUXL0400
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * AUXL0410
C                                                                   AUXL0420
      RETURN                                                        AUXL0430
      END                                                           AUXL0440
      SUBROUTINE DATA1(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)               AUXL0450
C                                                                   AUXL0460
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *APR1981
C                                                                   APR1981
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```
C ******* USER SUPPLIED DISPLACEMENT DATA SUBROUTINE CALLED BY PSAP1****APR1981
C                                                                        AUXL0480
C  *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *APR1981
      RETURN                                                             AUXL0490
      END                                                                AUXL0500

      SUBROUTINE DATA5(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT)
C *   *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
C
C***SUBROUTINE TO READ EACH NODE'S DISPLACEMENT FROM DEVICE 58
C *** CALLED BY PSAP1
C
C *   *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
C
      REAL*8 D(6)
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT,
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,
     2PSCALE,KDISP,DMAG,KODE
      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP
      COMMON/VALUES/ NVALUS
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)
      REWIND 58
      WRITE(6,10)NVALUS
10    FORMAT (///5X,'NUMBER OF DISPLACEMENT SETS TO BE PLOTTED =',I6///)
      DO 20 II=1,NVALUS
      READ(58)NODE,(D(I),I=1,6)
      R1=SNGL(D(1))
      R2=SNGL(D(2))
      R3=SNGL(D(3))
      UPT(II)=R1
      VPT(II)=R2
      WPT(II)=R3
20    CONTINUE
      RETURN
      END
      SUBROUTINE DATA9(NUMPT,XPT,YPT,ZPT,UPT,VPT,WPT,DISPD,NON)         0000362
C                                                                       0000363
C *   *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    * 0000364
C                                                                       0000365
C *** USER SUPPLIED DISPLACEMENT INPUT SUBROUTINE.                      0000366
C *** CALLED BY PSAP1                                                   0000367
C                                                                       0000368
C *   *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    * 0000369
C                                                                       0000370
      COMMON/CDATA/NTIME,NTLC                                           0000371
      COMMON/CONTRL/ KGEOM,KDATA,KPLOT,KSYMXY,KSYMXZ,KSYMYZ,NOTAT,XLHT,
     1KHORZ,KVERT,PHI,THETA,PSI,NEWFR,ISCALE,PLOTSZ,XORGN,YORGN,        0000373
     2PSCALE,KDISP,DMAG,KODE                                            0000374
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      COMMON/KOUNT/ NNODE,NNDEST,NUDISP,NVDISP,NWDISP                   0000375
      DIMENSION NUMPT(1),XPT(1),YPT(1),ZPT(1),UPT(1),VPT(1),WPT(1)      0000376
      DIMENSION DISPD(5,3,NON)                                          0000377
C                                                                       0000378
      IF (NUDISP.EQ.0.AND.NVDISP.EQ.0.AND.NWDISP.EQ.0) GO TO 25         0000379
      IF(NTIME.NE.0) GO TO 100                                          0000380
      READ(5,1000) NTLC,SCALEF                                          0000381
 1000 FORMAT( I5,F10.0)                                                 0000382
      IF(SCALEF.EQ.0) SCALEF=1.0                                        0000383
   10 READ(5,2000) N,NLCAS,U,V,W                                        0000384
 2000 FORMAT( 2I4,3E12.5)                                               0000385
      DISPD(NLCAS,1,N)  = U*SCALEF                                      0000386
      DISPD(NLCAS,2,N)  = V*SCALEF                                      0000387
      DISPD(NLCAS,3,N)  = W*SCALEF                                      0000388
      IF( (NLCAS.EQ.NTLC).AND.(N.EQ. 1    ) ) GO TO 100                 0000389
      GO TO 10                                                          0000390
  100 NTIME = NTIME + 1                                                 0000391
  200 DO 20 I=1,NNODE                                                   0000392
      UPT(I)  = DISPD(NTIME,1,I)                                        0000393
      VPT(I)  = DISPD(NTIME,2,I)                                        0000394
      WPT(I)  = DISPD(NTIME,3,I)                                        0000395
   20 CONTINUE                                                          0000396
   25 CONTINUE                                                          0000397
      RETURN                                                            0000398
      END                                                               0000399
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *APR1981
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * APR1981
C                                                                       APR1981
C        THE NEXT SEVEN SUBROUTINES ARE THE ADAPTIVE ROUTINES           APR1981
C        WHICH MODIFY PSAP1 FOR USE WITH THE VERSATEC PLOTTER           APR1981
C                                                                       APR1981
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   * APR1981
C                                                                       APR1981
C                                                                       APR1981
      SUBROUTINE CALCMP                                                 ADPT0010
C                                                                       APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *APR1981
C                                                                       APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PSAP1                      ADPT0020
C        INITIALIZES PLOTTER                                            APR1981
C        PLOTTER WINDOW SET TO 100" X 21.11"                            APR1981
C                                                                       APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *APR1981
C                                                                       APR1981
      CALL WINDOW(0.0,100.0,0.0,21.11)                                  ADPT0030
      CALL PLOTS(0,0,0)                                                 ADPT0040
      CALL PLOT(0.0,20.0,-3)                                            ADPT0050
      RETURN                                                            ADPT0060
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      END                                                                ADPT0070
      SUBROUTINE CALPLT(X,Y,IPEN)                                        ADPT0080
C                                                                        APR1981
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *  APR1981
C                                                                        APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PSAP1/PLOTX/GARROW/ERROR    ADPT0090
C        BASIC PLOTTING CALL                                             APR1981
C                                                                        APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *    *APR1981
C                                                                        APR1981
      INTEGER IPEN                                                       ADPT0100
      REAL X,Y                                                           APR1981
      CALL PLOT(Y,-X,IPEN)                                               APR1981
      RETURN                                                             ADPT0150
      END                                                                ADPT0160
      SUBROUTINE NOTATE (X,Y,HT,BCD,TH,N)                                ADPT0170
C                                                                        APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *    *APR1981
C                                                                        APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PSAP1                       ADPT0180
C        FOR LETTERING ON PLOT                                           APR1981
C                                                                        APR1981
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *  APR1981
C                                                                        APR1981
      INTEGER N                                                          ADPT0190
      REAL X,Y,HT,TH,THR                                                 APR1981
      DIMENSION BCD(1)                                                   ADPT0210
      THR=TH+270.0                                                       APR1981
      CALL SYMBOL(Y,-X,HT,BCD,THR,N)                                     APR1981
      RETURN                                                             ADPT0260
      END                                                                ADPT0270
      SUBROUTINE CALNUM (X,Y,HT,FPN,PH,DEC)                              ADPT0280
C                                                                        APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *    *APR1981
C                                                                        APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PLOTX                       ADPT0290
C        FOR NUMBERING ON PLOT                                           APR1981
C                                                                        APR1981
C  *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *    *APR1981
C                                                                        APR1981
      INTEGER DEC                                                        ADPT0300
      REAL X,Y,HT,PH,FPN,PHR                                             APR1981
      PHR=PH+270.0                                                       APR1981
      CALL NUMBER(Y,-X,HT,FPN,PHR,DEC)                                   APR1981
      RETURN                                                             ADPT0360
      END                                                                ADPT0370
      SUBROUTINE CALWH(X,Y)                                              ADPT0380
C                                                                        APR1981
```

```
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  APR1981
C                                                                                          APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PLOTX                                         ADPT0390
C        TO FIND CURRENT LOCATION OF PLOTTER PEN                                           APR1981
C                                                                                          APR1981
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  APR1981
C                                                                                          APR1981
      REAL X,Y,XR,YR,SCALE                                                                 APR1981
      CALL WHERE(XR,YR,SCALE)                                                              APR1981
      X=-YR                                                                                APR1981
      Y=XR                                                                                 APR1981
      RETURN                                                                               ADPT0440
      END                                                                                  ADPT0450
      SUBROUTINE CALINE(X,Y,N)                                                             ADPT0460
C                                                                                          APR1981
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  APR1981
C                                                                                          APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PLOTX                                         ADPT0470
C        TO DRAW A LINE THRU MULTIPLE POINTS                                               APR1981
C                                                                                          APR1981
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  APR1981
C                                                                                          APR1981
      INTEGER N,I                                                                          ADPT0480
      DIMENSION X(1),Y(1)                                                                  ADPT0500
      CALL PLOT(Y(1),-X(1),3)                                                              APR1981
      DO 100 I=2,N                                                                         ADPT0510
         CALL PLOT(Y(I),-X(I),2)                                                           APR1981
  100 CONTINUE                                                                             ADPT0550
      RETURN                                                                               ADPT0560
      END                                                                                  ADPT0570
      SUBROUTINE PSTOP                                                                     ADPT0580
C                                                                                          APR1981
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  APR1981
C                                                                                          APR1981
C ***** TO ADAPT FOR NPS VERSAPLOT CALLED BY PSAP1/ERROR                                   ADPT0590
C        TO CLOSE OUT PLOTTING DATA SETS                                                   APR1981
C                                                                                          APR1981
C *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *  APR1981
C                                                                                          APR1981
      CALL PLOT(0.,0.,999)                                                                 ADPT0600
      RETURN                                                                               ADPT0610
      END                                                                                  ADPT0620
```

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